

Healthcare Access and Quality Index based on mortality from causes amenable to personal health care in 195 countries and territories, 1990–2015: a novel analysis from the Global Burden of Disease Study 2015



GBD 2015 Healthcare Access and Quality Collaborators*



Summary

Background National levels of personal health-care access and quality can be approximated by measuring mortality rates from causes that should not be fatal in the presence of effective medical care (ie, amenable mortality). Previous analyses of mortality amenable to health care only focused on high-income countries and faced several methodological challenges. In the present analysis, we use the highly standardised cause of death and risk factor estimates generated through the Global Burden of Diseases, Injuries, and Risk Factors Study (GBD) to improve and expand the quantification of personal health-care access and quality for 195 countries and territories from 1990 to 2015.

Methods We mapped the most widely used list of causes amenable to personal health care developed by Nolte and McKee to 32 GBD causes. We accounted for variations in cause of death certification and misclassifications through the extensive data standardisation processes and redistribution algorithms developed for GBD. To isolate the effects of personal health-care access and quality, we risk-standardised cause-specific mortality rates for each geography-year by removing the joint effects of local environmental and behavioural risks, and adding back the global levels of risk exposure as estimated for GBD 2015. We employed principal component analysis to create a single, interpretable summary measure—the Healthcare Quality and Access (HAQ) Index—on a scale of 0 to 100. The HAQ Index showed strong convergence validity as compared with other health-system indicators, including health expenditure per capita ($r=0.88$), an index of 11 universal health coverage interventions ($r=0.83$), and human resources for health per 1000 ($r=0.77$). We used free disposal hull analysis with bootstrapping to produce a frontier based on the relationship between the HAQ Index and the Socio-demographic Index (SDI), a measure of overall development consisting of income per capita, average years of education, and total fertility rates. This frontier allowed us to better quantify the maximum levels of personal health-care access and quality achieved across the development spectrum, and pinpoint geographies where gaps between observed and potential levels have narrowed or widened over time.

Findings Between 1990 and 2015, nearly all countries and territories saw their HAQ Index values improve; nonetheless, the difference between the highest and lowest observed HAQ Index was larger in 2015 than in 1990, ranging from 28.6 to 94.6. Of 195 geographies, 167 had statistically significant increases in HAQ Index levels since 1990, with South Korea, Turkey, Peru, China, and the Maldives recording among the largest gains by 2015. Performance on the HAQ Index and individual causes showed distinct patterns by region and level of development, yet substantial heterogeneities emerged for several causes, including cancers in highest-SDI countries; chronic kidney disease, diabetes, diarrhoeal diseases, and lower respiratory infections among middle-SDI countries; and measles and tetanus among lowest-SDI countries. While the global HAQ Index average rose from 40.7 (95% uncertainty interval, 39.0–42.8) in 1990 to 53.7 (52.2–55.4) in 2015, far less progress occurred in narrowing the gap between observed HAQ Index values and maximum levels achieved; at the global level, the difference between the observed and frontier HAQ Index only decreased from 21.2 in 1990 to 20.1 in 2015. If every country and territory had achieved the highest observed HAQ Index by their corresponding level of SDI, the global average would have been 73.8 in 2015. Several countries, particularly in eastern and western sub-Saharan Africa, reached HAQ Index values similar to or beyond their development levels, whereas others, namely in southern sub-Saharan Africa, the Middle East, and south Asia, lagged behind what geographies of similar development attained between 1990 and 2015.

Interpretation This novel extension of the GBD Study shows the untapped potential for personal health-care access and quality improvement across the development spectrum. Amid substantive advances in personal health care at the national level, heterogeneous patterns for individual causes in given countries or territories suggest that few places have consistently achieved optimal health-care access and quality across health-system functions and therapeutic areas. This is especially evident in middle-SDI countries, many of which have recently undergone or are currently experiencing epidemiological transitions. The HAQ Index, if paired with other measures of health-system

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*Collaborators listed at the end of the Article

Correspondence to:
Prof Christopher J L Murray,
Institute for Health Metrics and
Evaluation, University of
Washington, 2301 5th Avenue,
Suite 600, Seattle, WA 98121,
USA
cjlm@uw.edu

characteristics such as intervention coverage, could provide a robust avenue for tracking progress on universal health coverage and identifying local priorities for strengthening personal health-care quality and access throughout the world.

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Introduction

Quantifying how much personal health care can improve population health and ultimately health-system performance is a crucial undertaking, particularly following the inclusion of universal health coverage (UHC) in the Sustainable Development Goals (SDGs).¹ Mortality from causes considered amenable to personal health care serve as an important proxy of health-care access and quality (panel),^{4,6–8} and thus can be used to benchmark

dimensions of health-system performance and to identify untapped potential for advancing personal health-care access and quality.^{9–12} Much debate exists concerning the relative contributions of personal health care, population-level health initiatives, and social determinants to population health.^{13–16} Studies show that access to high-quality health care substantially improves many health outcomes, including infectious diseases (eg, tuberculosis and measles);^{17–19} maternal and neonatal disorders;^{20,21}

Research in context

Evidence before this study

In the last several decades, various studies have used measures of amenable mortality, or deaths that could be avoided in the presence of high-quality personal health care, to garner signals about health-system delivery, effectiveness, and performance. Rutstein and colleagues developed an initial list of conditions from which death was “unnecessary and untimely” during the late 1970s, while Charlton and colleagues were the first to apply this concept to population-level analyses in England and Wales. Although variations of amenable cause lists exist today, the most widely used cause list of 33 conditions was developed and further honed by Nolte and McKee during the early-to-mid 2000s. Such analyses of health-care access and quality, as approximated by amenable mortality, have been limited to Europe, Organisation for Economic Co-operation and Development (OECD) countries, and country-specific assessments, including the USA, Australia, and New Zealand. These studies acknowledge several methodological challenges that may impede the policy utility and applications of their results. Heterogeneity in cause of death certification and misclassification, even for countries with complete vital registration systems, can hinder comparability of results over time and place. Further, researchers commonly acknowledge that variations in measured amenable mortality rates may be more reflective of differences in underlying risk factor exposure rather than true differences in personal health-care access and quality.

Added value of this study

The Global Burden of Diseases, Injuries, and Risk Factors Study (GBD) provides an appropriate analytic framework through which these main challenges in approximating personal health-care access and quality can be addressed. First, the extensive cause of death data processing and standardisation that occur within GBD allow for the systematic identification and redress of cause of death certification errors or misclassification. These adjustments are conducted across all geographies and over time, accounting for known misclassification patterns and applying well established redistribution algorithms for causes

designated to so-called garbage codes, or causes of death that could not or should not be classified as underlying causes of death. Second, we draw on GBD’s comparative risk assessment analyses to risk-standardise national cause-specific mortality rates to global levels of risk exposure; this step helps to remove variations in death rates due to risk exposure rather than differences in personal health-care access and quality. Third, we construct the Healthcare Access and Quality (HAQ) Index based on risk-standardised cause-specific death rates to facilitate comparisons over time and by geography. Finally, we produced a HAQ Index frontier to enable a better understanding of the maximum observed levels of the HAQ Index across the development spectrum, and what untapped potential for improving personal health-care access and quality may exist given a country or territory’s current resources.

Implications of all the available evidence

Our results point to substantive gains for advancing personal health-care access and quality throughout the world since 1990. However, the gap between places with the highest and lowest HAQ Index in 1990 increased by 2015, suggesting that geographic inequalities in personal health-care access and quality might be on the rise. In 2015, countries in western Europe generally had the highest HAQ Index values while geographies in sub-Saharan Africa and Oceania mainly saw the lowest, further emphasising these disparities. A number of countries achieved improvements in the HAQ Index that exceeded the average found for their development level, identifying possible success stories in markedly advancing personal health-care access and quality at the national level. Based on our frontier analysis, many countries and territories currently experience untapped potential for improving health-care access and quality, on the basis of their development, a finding that could be transformative for prioritising particular health-sector reforms, pinpointing cause-specific therapeutic areas that require more policy attention, and monitoring overall progress toward universal health coverage.

several cancers (eg, testicular, skin, and cervical cancers);^{22,23} and many non-communicable diseases (NCDs) such as cerebrovascular disease (stroke),²⁴ diabetes,²⁵ and chronic kidney disease.²⁶ Consequently, assessing mortality rates from these conditions, which are considered amenable to personal health care,^{4,6–8} can provide vital insights into access to and quality of health care worldwide. Assessments of both mortality and disease burden attributable to risk factors modifiable through public health programmes and policy (eg, tobacco taxation), combined with access to high-quality personal health care, can provide a more complete picture of the potential avenues for health improvement.

In the late 1970s, Rutstein and colleagues first introduced the idea of “unnecessary, untimely deaths”, proposing a list of causes from which death should not occur with timely and effective medical care.⁶ Eventually termed “amenable mortality”, this approach has been modified and extended since, with researchers refining the list of included conditions by accounting for advances in medical care, the introduction of new interventions, and improved knowledge of cause-specific epidemiology.^{7,8,27–29} Numerous studies have subsequently assessed amenable mortality trends over time, by sex, and across ages in different populations;^{2,10,11,30–33} examples include analyses showing variations in amenable mortality within the European Union and Organisation for Economic Co-operation and Development (OECD),^{3,34} and how much the US health system has lagged behind other higher-income countries.^{30,31} Some studies also extended the set of amenable conditions to include those targeted by public health programmes.³¹ The most widely cited and utilised list of causes amenable to personal health care is that of Nolte and McKee,⁴ which has been extensively used in Europe, the USA, and other OECD countries.^{9,11,30,31,35}

Previously, several technical challenges have emerged concerning the quantification of mortality from conditions amenable to personal health care and its use for understanding overall health-care access and quality. First, discrepancies in cause of death certification practices and misclassification over time and across geographies affect comparisons of amenable mortality.^{4,36} Second, observed geographic and temporal variations in deaths from selected amenable causes (eg, stroke and heart disease) might be attributed partly differences in risk factor exposure (eg, diet, high BMI, and physical activity) rather than actual differences in access to quality personal health care. Public health programmes and policies might modify these risks in well-functioning health systems, but risk variation can still confound the measurement of personal health-care access and quality. Third, much of this work has occurred in higher-income settings, with few studies applying the concept of amenable mortality as a mechanism for assessing access and quality to personal health care in lower-resource settings. Other critiques involve weak correlations between observed trends and variations in amenable mortality and indicators of health-care provision and spending, although this result could

Panel: Context and definitions

With the present analysis, we use the Global Burden of Diseases, Injuries, and Risk Factors Study (GBD) to approximate average levels of personal health-care access and quality for 195 countries and territories from 1990 to 2015. Here we define key concepts frequently used in the literature focused on assessing health-care quality and how they relate to GBD terminology:

Avertable burden refers to disease burden that could be avoided in the presence of high-quality personal health care in addition to disease burden that could be prevented through effective public health (ie, non-personal) interventions.

Amenable burden entails disease burden that could be avoided in the presence of high-quality personal health care.²³ To be considered a cause amenable to personal health care, effective interventions must exist for the disease.⁴ The most widely used and cited list of causes amenable to health care is that of Nolte and McKee.

Preventable burden involves disease burden that could be avoided through public health programmes or policies focused on wider determinants of health, such as behavioural and lifestyle influences, environmental factors, and socioeconomic status.²³ For some causes, both personal health care and public health programmes and policies can reduce burden.

Within the GBD framework, we have two related terms: attributable and avoidable burden.⁵

Attributable burden refers to the difference in disease burden observed at present and burden that would have been observed in a population if past exposure was at the lowest level of risk.

Avoidable burden concerns the reduction in future disease burden if observed levels of risk factor exposure today were decreased to a counterfactual level.

For this study, we use the definition of amenable burden and focus on amenable mortality to provide a signal on approximate average levels of national personal health-care access and quality. Future analyses facilitated through the GBD study aim to provide more comprehensive assessments of health systems using amenable burden and preventable burden.

Garbage codes refer to causes certified by physicians on death certificates that cannot or should not be considered the actual underlying causes of death. Examples include risk factors like hypertension, non-fatal conditions like yellow nails, and causes that are on the final steps of a disease pathway (eg, certifying cardiopulmonary arrest as the cause when ischaemic heart disease is the true underlying cause of death). A vital strength of the GBD Study is its careful identification of garbage codes by cause, over time, and across locations, and subsequent redistribution to underlying causes based on the GBD cause list.

Risk-standardisation involves removing the joint effects of environmental and behavioural risk exposure on cause-specific mortality rates at the country or territory level for each year of analysis, and then adding back the global average of environmental and behavioural risk exposure for every geography-year. The goal of risk-standardisation is to eliminate geographic or temporal differences in cause-specific mortality due to variations in risk factors that are not immediately targeted by personal health care—and thus provide comparable measures of outcomes amenable to personal health-care access and quality over place and time.

Frontier analysis refers to the approach used for ascertaining the highest achieved values on the Healthcare Access and Quality Index (HAQ Index) on the basis of development status, as measured by the Socio-demographic Index (SDI). The HAQ Index frontier delineates the maximum HAQ Index reached by a location as it relates to SDI; if a country or territory falls well below the frontier value given its level SDI, this finding suggests that greater gains in personal health-care access and quality should be possible based on the country or territory's place on the development spectrum.

	Amenable age range (years)
Communicable, maternal, neonatal, and nutritional diseases	
Tuberculosis	0–74
Diarrhoea, lower respiratory, and other common infectious diseases	
Diarrhoeal diseases	0–14
Lower respiratory infections	0–74
Upper respiratory infections	0–74
Diphtheria	0–74
Whooping cough	0–14
Tetanus	0–74
Measles	1–14
Maternal disorders	0–74
Neonatal disorders	0–74
Non-communicable diseases	
Neoplasms	
Colon and rectum cancer	0–74
Non-melanoma skin cancer (squamous-cell carcinoma)	0–74
Breast cancer	0–74
Cervical cancer	0–74
Uterine cancer	0–44
Testicular cancer	0–74
Hodgkin's lymphoma	0–74
Leukaemia	0–44
Cardiovascular diseases	
Rheumatic heart disease	0–74
Ischaemic heart disease	0–74
Cerebrovascular disease	0–74
Hypertensive heart disease	0–74
Chronic respiratory diseases	1–14
Digestive diseases	
Peptic ulcer disease	0–74
Appendicitis	0–74
Inguinal, femoral, and abdominal hernia	0–74
Gallbladder and biliary diseases	0–74
Neurological disorders	
Epilepsy	0–74
Diabetes, urogenital, blood, and endocrine diseases	
Diabetes mellitus	0–49
Chronic kidney disease	0–74
Other non-communicable diseases	
Congenital heart anomalies	0–74
Injuries	
Unintentional injuries	
Adverse effects of medical treatment	0–74
The age groups for which mortality is regarded as amenable to health care are listed. Causes are ordered on the basis of the GBD cause list and corresponding cause group hierarchies. GBD=Global Burden of Disease.	
Table 1: Causes for which mortality is amenable to health care mapped to GBD 2015 causes	

occur if health-care quality is heterogeneous within countries.^{37–40} Additionally, existing lists might exclude causes for which health care can avert death, such as the

effects of trauma care on various injuries,^{41,42} and the ages at which personal health care can reduce mortality, namely beyond the age of 75.^{43,44}

The goal of this analysis is to use estimates of mortality amenable to personal health care from the Global Burden of Diseases, Injuries, and Risk Factors Study 2015 (GBD 2015) to approximate access to and quality of personal health care in 195 countries and territories from 1990 to 2015. Quantifying access to and quality of personal health care has many policy uses, and no consistent measures of personal health-care access and quality currently list across the development spectrum; for instance, the World Bank coverage index only includes three interventions,⁴⁵ and the 2010–11 International Labour Organization's indicator of formal health coverage covered 93 countries, with substantial data missingness for sub-Saharan Africa.⁴⁶ The highly standardised cause of death estimates generated through GBD,⁴⁷ along with risk factor exposure,⁴⁸ can address several limitations associated with previous studies of amenable mortality. GBD provides comprehensive, comparable estimates of cause-specific death rates by geography, year, age, and sex through its extensive data correction processes to account for variations in cause of death certification.⁴⁷ The quantification of risk exposure and risk-attributable deaths due to 79 risk factors through GBD allows us to account for variations in risk exposure across geographies and time,⁴⁸ and thus helps to isolate variations in death rates due to personal health-care access and quality. We also examine the relationship between our measure of health-care access and quality, as defined by risk-standardised mortality rates amenable to health care, across development levels, as reflected by the Socio-demographic Index (SDI). Finally, we produce a frontier of maximum levels of personal health-care access and quality observed on the basis of SDI, which allows us to quantify the potential for further improvement in relation to development status.

Methods

Overview

We employed the most widely cited and used framework for assessing mortality amenable to personal health care.^{4,9,11,30,31,35} The Nolte and McKee cause list does not include all possible causes for which health care can improve survival; however, it does provide a set of conditions for which there is a reasonable consensus that personal health care has a major effect (table 1). Starting with this list, our analysis followed four steps: mapping the Nolte and McKee cause list to GBD causes; risk-standardising mortality rates to remove variations in death rates not easily addressed through personal health care; computing a summary measure of personal health-care access and quality using principal component analysis (PCA); and assessing the highest recorded levels of health-care access and quality across the development spectrum.

This study draws from GBD 2015 results; further detail on GBD 2015 data and methods are available

	Source and year	Geographies represented	HAQ Index construction			
			PCA weighted	EFA weighted	Geometric mean	Mean
Health expenditure per capita	GBD 2015	195	0.884	0.880	0.854	0.864
Hospital beds (per 1000)	GBD 2015	195	0.700	0.683	0.625	0.650
UHC tracer index of 11 interventions	GBD 2015	188	0.826	0.820	0.812	0.818
Physicians, nurses, and midwives per 1000	WHO 2010	73	0.769	0.755	0.725	0.732
Proportion of population with formal health coverage	ILO 2010–11	93	0.808	0.798	0.773	0.781
Coverage index of three primary health-care interventions	World Bank 2015	123	0.601	0.589	0.557	0.570

The universal health coverage tracer index of 11 interventions included coverage of four childhood vaccinations (BCG, measles, three doses of diphtheria-pertussis-tetanus, and three doses of polio vaccines); skilled birth attendance; coverage of at least one and four antenatal care visits; met need for family planning with modern contraception; tuberculosis case detection rates; insecticide-treated net coverage; and antiretroviral therapy coverage for populations living with HIV. The World Bank coverage index included coverage of three interventions: three doses of diphtheria-pertussis-tetanus vaccine; at least four antenatal care visits; and children with diarrhoea receiving appropriate treatment. HAQ Index=Healthcare Access and Quality Index. PCA=principal components analysis. EFA=exploratory factor analysis. GBD=Global Burden of Disease. UHC=universal health coverage. ILO=International Labour Organization.

Table 2: Correlations between different constructions of the HAQ Index and existing indicators of health-care access or quality

elsewhere.^{47–50} For the present analysis, a vital strength of GBD is its careful evaluation and correction of cause of death certification problems and misclassification at the national level. In the GBD, we systematically identified causes of death that could not or should not be underlying causes of death (so-called garbage codes), and applied established statistical algorithms to correct for and redistribute these deaths.⁵¹

Our study complies with the Guidelines for Accurate and Transparent Health Estimates Reporting (GATHER);⁵² additional information on the data and modelling strategies used can be found in the appendix.

Mapping the Nolte and McKee amenable cause list to the GBD cause list

Drawing from Nolte and McKee's list of 33 causes amenable to personal health care,^{4,9,11,30,31,35} we mapped these conditions to the GBD cause list based on corresponding International Classification of Diseases (ICD) codes (appendix p 18). In GBD, thyroid diseases and benign prostatic hyperplasia are part of a larger residual category and thus were excluded. Diphtheria and tetanus are separate causes in GBD so we reported them individually. Because of its extensive processes used to consistently map and properly classify ICD causes over time,^{47,53} GBD supported the assessment of 32 causes on the Nolte and McKee cause list from 1990 to 2015.

Age-standardised risk-standardised death rates

Some variation in death rates for amenable causes are due to differences in behavioural and environmental risk exposure rather than differences in personal health-care access and quality.^{48,54,55} Using the wide range of risk factors assessed by GBD,⁴⁸ we risk-standardised death rates to the global level of risk exposure.⁴⁸ We did not risk-standardise for variations in metabolic risk factors directly targeted by personal health care: systolic blood pressure, total cholesterol, and fasting plasma glucose. For example,

stroke deaths due to high systolic blood pressure are amenable to primary care management of hypertension.

To risk-standardise death rates, we removed the joint effects of national behavioural and environmental risk levels calculated in GBD, and added back the global levels of risk exposure:

$$mr_{jascy} = m_{jascy} \left(\frac{1 - JPAF_{jascy}}{1 - JPAF_{jascy}^g} \right)$$

where m_{jascy} is the death rate from cause j in age a , sex s , location c , and year y ; mr_{jascy} is the risk-standardised death rate; $JPAF_{jascy}$ is the joint population attributable fraction (PAF) for cause j , in age a , sex s , country c , and year y for all behavioural and environmental risks included in GBD; and $JPAF_{jascy}^g$ is the joint PAF for cause j , in age a , sex s , and year y at the global level.

GBD provides joint PAF estimation for multiple risks combined, which takes into account the mediation of different risks through each other. Further detail on joint PAF computation is available in the appendix (pp 5–8).

We used the GBD world population standard to calculate age-standardised risk-standardised death rates from each cause regarded as amenable to health care.⁴⁷ We did not risk-standardise death rates from diarrhoeal diseases as mortality attributable to unsafe water and sanitation was not computed for high-SDI locations; such standardisation could lead to higher risk-standardised death rates in those countries compared with countries where mortality was attributed to unsafe water and sanitation.⁴⁸ With all causes for which no PAFs are estimated in GBD, such as neonatal disorders and testicular cancer, risk-standardised death rates equalled observed death rates.

The effects of risk-standardisation are highlighted by comparing the log of age-standardised mortality rates to

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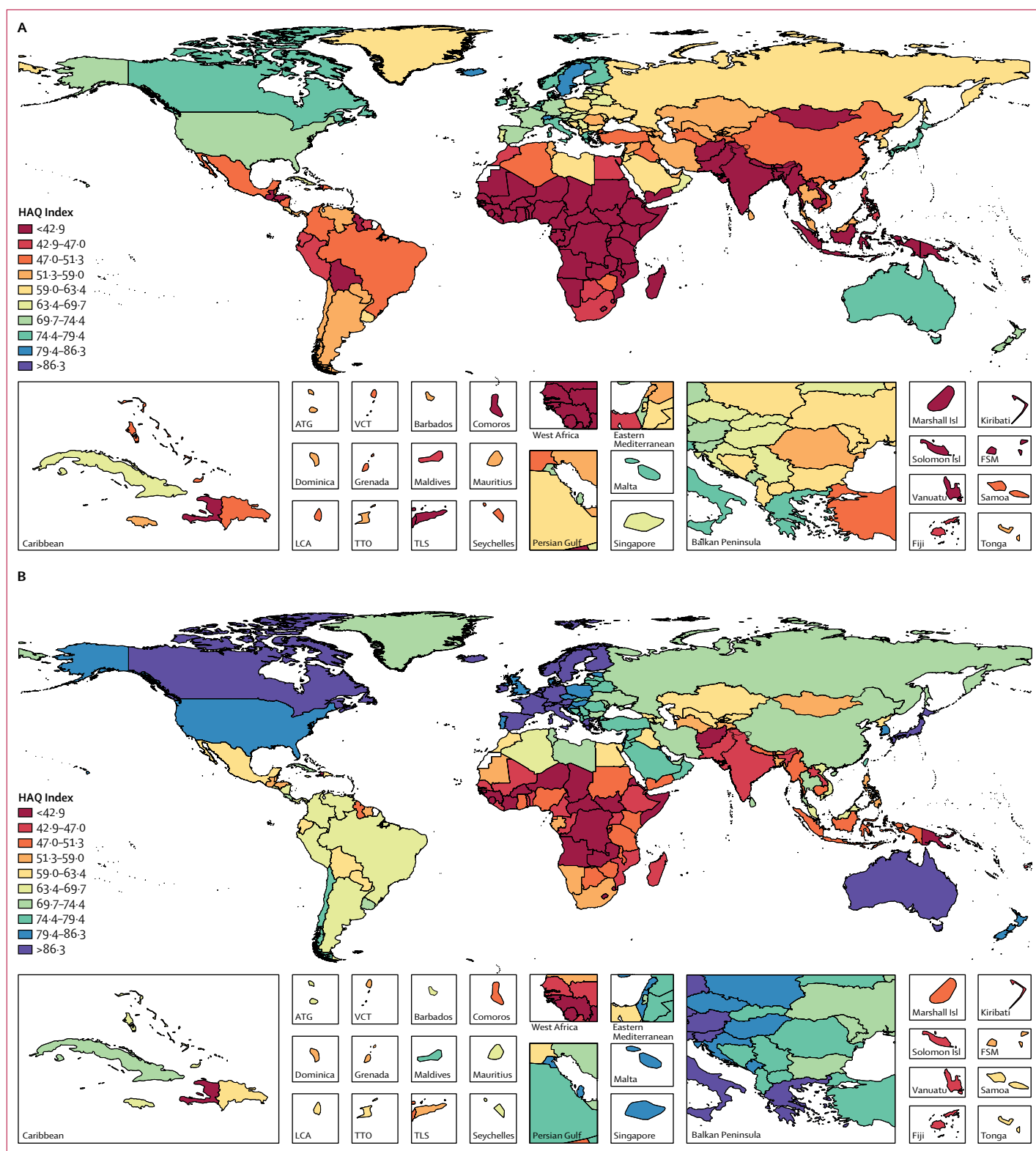


Figure 1: Map of HAQ Index values, by decile, in 1990 (A) and 2015 (B)

Deciles were based on the distribution of HAQ Index values in 2015 and then were applied for 1990. HAQ Index = Healthcare Access and Quality Index. ATG=Antigua and Barbuda. VCT=Saint Vincent and the Grenadines. LCA=Saint Lucia. TTO=Trinidad and Tobago. TLS=Timor-Leste. FSM=Federated States of Micronesia.

the log of age-standardised risk-standardised mortality rates for amenable causes (appendix p 14). For each SDI quintile, many countries had differing levels of age-standardised mortality rates but their risk-standardised mortality rates were similar, demonstrating how underlying local risk exposure can skew measures of mortality amenable to personal health care.

Construction of the Healthcare Access and Quality Index based on age-standardised risk standardised death rates

To construct the Healthcare Access and Quality (HAQ) Index, we first rescaled the log age-standardised risk-standardised death rate by cause to a scale of 0 to 100 such that the highest observed value from 1990 to 2015 was 0 and the lowest was 100. To avoid the effects of fluctuating death rates in small populations on rescaling, we excluded populations less than 1 million population from setting minimum and maximum values. Any location with a cause-specific death rate below the minimum or above the maximum from 1990 to 2015 was set to 100 or 0, respectively.

Because each included cause provided some signal on average levels of personal health-care access and quality, we explored four approaches to construct the HAQ Index: PCA, exploratory factor analysis, arithmetic mean, and geometric mean. Details on these four approaches are in the appendix (pp 7, 8, 21, 22). All four measures were highly correlated, with Spearman's rank order correlations exceeding $r_s=0.98$. We selected the PCA-derived HAQ Index because it provided the strongest correlations with six other currently available cross-country measures of access to care or health-system inputs (table 2). Three indicators came from the GBD Study 2015: health expenditure per capita, hospital beds per 1000, and the UHC tracer intervention index, a composite measure of 11 UHC tracer interventions (four childhood vaccinations; skilled birth attendance; coverage of at least one and four antenatal care visits; met need for family planning with modern contraception; tuberculosis case detection rates; insecticide-treated net coverage; and antiretroviral therapy coverage for populations living with HIV).⁵⁶ Three indicators came from WHO (physicians, nurses, and midwives per 1000),⁵⁷ the International Labour Organization,⁴⁶ and the World Bank (coverage index based on diphtheria-pertussis-tetanus vaccine coverage, coverage of at least four antenatal care visits, and proportion of children with diarrhoea receiving appropriate treatment).⁴⁵ All indicators had correlation coefficients greater than 0.60, and three exceeded 0.80 (health expenditure per capita, the UHC tracer index, and International Labour Organization formal health coverage).

The appendix (pp 21, 22) provides final rescaled PCA weights derived from the first five components that collectively accounted for more than 80% of the variance in cause-specific measures. Colon and breast cancer had negative PCA weights, which implied higher death rates

were associated with better access and quality of care; because this cannot be true we set these weights to zero in the final PCA-derived HAQ Index. The appendix (p 15) compares each geography's HAQ Index in 2015 with the log of its age-standardised risk-standardised mortality rates.

Quantifying maximum levels of the HAQ Index across the development spectrum

To better understand maximum levels of personal health-care access and quality potentially achievable across the development spectrum, we produced a frontier based on the relationship between the HAQ Index and SDI. We tested both stochastic frontier analysis models and data envelopment analysis; however, the relationship between SDI and the HAQ Index did not fit standard stochastic frontier analysis models,⁵⁸ and data envelopment analysis cannot account for measurement error and is sensitive to outliers.⁵⁹ To generate a frontier fit that closely follows the observed HAQ Index and allowed for measurement error, we used free disposal hull analysis on 1000 bootstrapped samples of the data.⁵⁸ Every bootstrap included a subset of locations produced by randomly sampling (with replacement) from all GBD geographies. The final HAQ Index value was drawn from the uncertainty distribution for each location-year, with outliers removed by excluding super-efficient units; additional methodological detail can be found in the appendix (pp 9–12). Last, we used a Loess regression to produce a smooth frontier for each five-year interval from 1990 to 2015. For every geography, we report the maximum possible HAQ Index value on the basis of SDI in 1990 and 2015, while values for all years can be found in the appendix (pp 23–28).

Uncertainty analysis

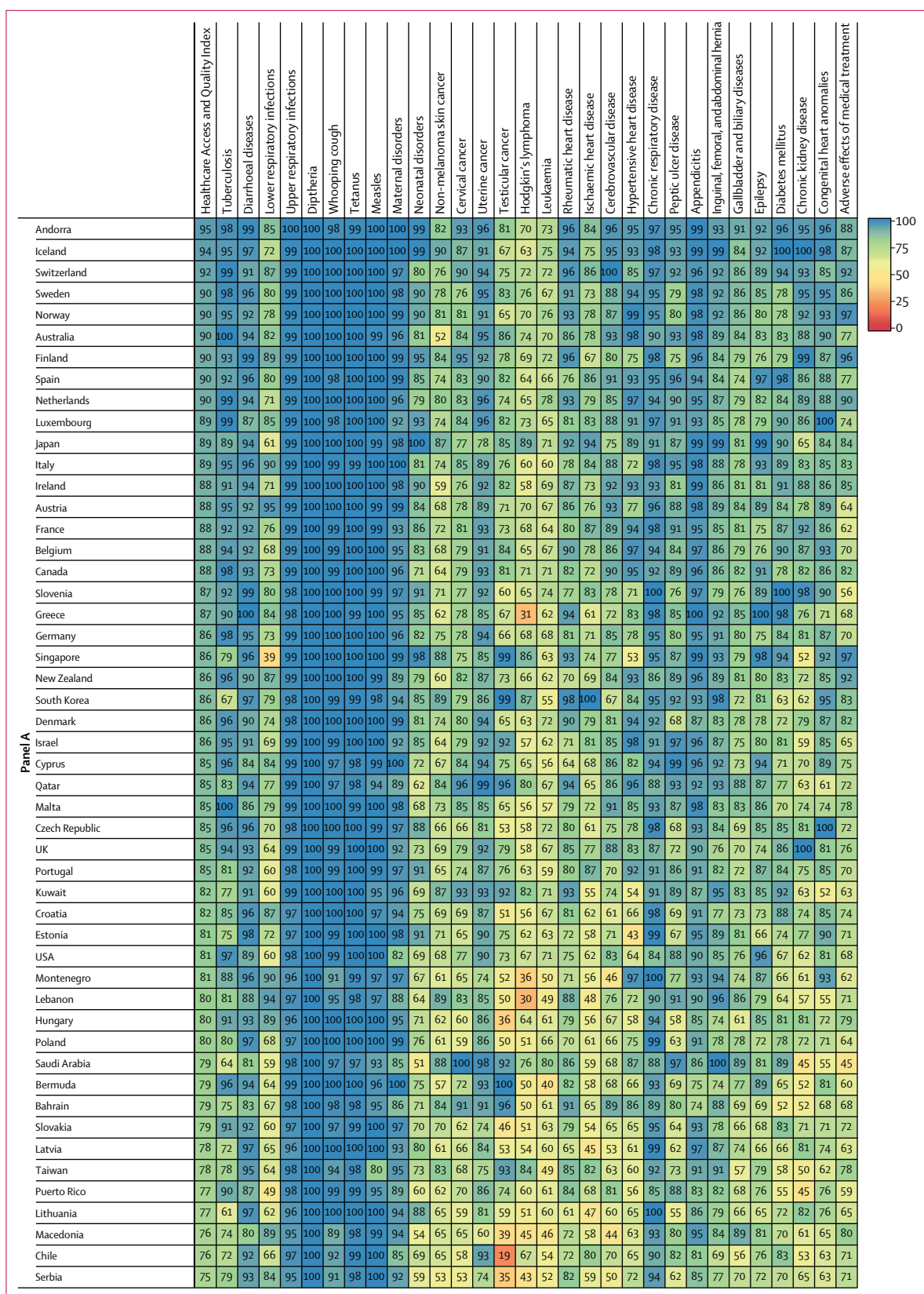
GBD aims to propagate all sources of uncertainty through its estimation process,^{47,48} which results in uncertainty intervals (UIs) accompanying each point estimate of death by cause, geography, year, age group, and sex. We computed the HAQ Index for each geography-year based on 1000 draws from the posterior distribution for each included cause of death. We report 95% UIs based on the ordinal 25th and 975th draws for each quantity of interest.

Role of the funding source

The funder of the study had no role in study design, data collection, data analysis, data interpretation, or writing of the report. The corresponding author had full access to all the data in the study and had final responsibility for the decision to submit for publication.

Results

Distinct geographic patterns emerged for overall HAQ Index levels and gains from 1990 to 2015 (figure 1). Andorra and Iceland had the highest HAQ Index in 1990, whereas most of sub-Saharan Africa and south Asia and



(Figure 2 continues on next page)

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	Healthcare Access and Quality Index																															
	Tuberculosis																															
	Diarrhoeal diseases																															
	Lower respiratory infections																															
	Upper respiratory infections																															
	Diphtheria																															
	Whooping cough																															
	Tetanus																															
	Measles																															
	Maternal disorders																															
	Neonatal disorders																															
	Non-melanoma skin cancer																															
	Cervical cancer																															
	Uterine cancer																															
	Testicular cancer																															
	Hodgkin's lymphoma																															
	Leukaemia																															
	Rheumatic heart disease																															
	Ischaemic heart disease																															
	Cerebrovascular disease																															
	Hypertensive heart disease																															
	Chronic respiratory disease																															
	Peptic ulcer disease																															
	Appendicitis																															
	Inguinal, femoral, and abdominal hernia																															
	Gallbladder and biliary diseases																															
	Epilepsy																															
	Diabetes mellitus																															
	Chronic kidney disease																															
	Congenital heart anomalies																															
	Adverse effects of medical treatment																															
Panel B cont.	Mexico	63	67	69	53	95	100	95	99	100	70	48	56	53	88	34	54	31	75	63	67	65	74	60	56	51	42	69	40	13	41	63
	Saint Lucia	63	64	72	44	94	100	96	96	100	70	42	69	47	85	64	55	41	58	63	47	47	62	66	66	72	68	57	43	37	53	44
	Dominican Republic	62	56	60	50	94	99	84	81	100	67	31	47	53	77	96	75	54	71	47	46	48	62	58	73	82	87	77	53	39	47	35
	Uzbekistan	62	50	75	36	89	99	91	98	100	76	39	72	63	83	71	59	30	39	30	41	24	95	48	80	85	67	47	53	54	61	59
	Samoa	62	62	90	44	89	91	65	98	68	61	66	89	62	78	27	62	53	40	46	52	51	76	59	60	75	47	75	37	25	75	44
	Tonga	62	69	80	34	86	100	94	98	87	51	45	50	86	99	78	72	48	48	48	55	62	67	38	35	55	24	83	36	99	54	41
	Ecuador	61	54	65	35	94	99	90	94	100	68	49	57	48	75	59	52	33	68	67	62	50	76	62	53	63	43	66	58	28	48	56
	Egypt	61	73	54	49	91	100	92	87	88	67	51	82	87	80	87	84	29	54	37	47	54	78	54	67	65	34	66	60	31	20	43
	Paraguay	60	58	65	50	92	99	89	93	100	58	43	49	38	85	47	55	37	77	61	52	55	68	64	56	48	71	55	31	47	50	
	Kyrgyzstan	60	46	58	42	83	99	87	99	98	66	30	54	50	68	65	65	50	40	30	31	54	94	58	79	77	60	46	71	47	45	64
	Bolivia	59	50	52	31	90	99	89	98	100	50	30	59	37	53	72	70	35	58	63	54	76	82	62	54	72	46	75	62	23	65	37
	Mongolia	59	45	95	43	87	99	90	98	100	65	33	47	47	70	87	75	54	39	34	26	58	71	31	55	70	38	52	64	41	42	66
	Belize	58	54	66	39	91	99	89	93	100	73	44	52	38	65	91	53	42	59	47	44	43	65	58	63	60	51	62	40	27	64	28
	Dominica	58	59	59	38	93	99	94	89	100	75	31	54	51	83	97	47	25	65	57	49	34	58	59	72	66	68	45	38	25	47	33
	Saint Vincent and the Grenadines	57	64	63	41	92	100	90	98	100	75	34	45	36	88	88	42	24	58	48	43	38	71	44	63	63	54	52	33	35	49	42
	Suriname	57	72	57	46	93	98	82	91	100	70	27	70	45	92	69	51	37	65	52	39	48	50	50	61	44	51	58	49	30	42	24
	Federated States of Micronesia	54	54	82	31	79	98	77	98	89	57	56	45	51	58	73	68	40	26	28	31	35	70	46	46	68	36	66	27	14	66	37
	Namibia	54	21	36	26	89	99	90	93	78	53	25	93	56	92	78	82	89	47	57	47	35	61	54	62	58	43	27	40	40	77	52
	South Africa	52	24	45	24	90	98	87	95	65	53	29	23	33	92	70	62	64	49	57	49	39	63	54	64	58	40	27	34	38	76	55
	Philippines	52	32	56	34	88	99	97	73	72	61	38	63	59	54	79	78	24	47	45	37	32	44	32	61	68	56	82	42	18	38	63
Gabon	51	40	54	24	89	97	83	81	75	44	24	72	42	82	74	74	59	47	54	35	38	64	49	53	54	36	46	38	54	46	47	
Botswana	51	21	46	24	88	99	96	93	86	53	33	24	29	88	65	62	65	46	54	42	36	68	49	57	51	36	25	32	37	78	46	
Guyana	50	47	51	36	86	99	87	92	100	57	29	62	38	64	77	53	41	52	31	25	28	65	43	44	50	45	53	27	29	49	29	
Indonesia	49	27	52	56	90	98	81	54	60	52	36	61	56	73	94	57	38	59	51	27	44	74	40	42	26	35	69	31	31	52	50	
Fiji	47	56	54	23	83	98	85	98	63	59	35	66	41	61	45	57	20	21	24	40	29	56	48	42	64	41	55	7	9	33	41	
Swaziland	42	16	29	15	78	98	88	91	79	46	25	14	19	86	63	55	59	30	40	31	28	53	39	46	44	27	15	19	27	70	37	
Panel C	Syria	75	86	85	57	92	99	79	95	77	64	54	85	91	81	95	77	63	83	36	48	75	54	93	76	93	78	89	81	74	34	67
	Palestine	70	99	85	46	89	99	84	98	83	76	38	82	94	69	90	35	31	72	36	48	47	88	96	72	97	85	63	71	26	48	63
	Nicaragua	64	60	63	55	91	100	88	98	100	65	51	60	44	92	64	67	35	84	68	65	54	70	66	61	59	62	72	51	12	57	69
	Algeria	64	56	66	52	95	100	95	96	86	63	33	84	67	93	93	56	51	67	58	54	56	86	67	60	55	68	66	51	43	54	44
	North Korea	62	53	81	64	79	99	81	87	79	68	45	62	63	49	84	64	19	36	61	28	43	88	53	81	92	61	66	63	41	40	71
	Cape Verde	62	54	61	35	89	99	91	95	88	69	30	90	43	85	72	88	39	68	59	38	59	81	74	62	64	64	45	57	42	53	53
	Morocco	61	46	71	43	92	100	89	91	88	64	34	62	58	52	94	57	46	57	56	53	57	80	70	70	76	61	59	47	38	49	44
	Iraq	60	53	60	51	90	98	80	94	89	57	33	68	76	56	77	79	10	47	24	37	50	83	75	84	93	77	66	36	29	31	51
	Tajikistan	59	48	44	34	84	99	80	98	100	72	33	74	80	72	79	60	42	41	35	38	47	79	48	72	72	71	39	53	48	44	57
	Guatemala	56	62	45	27	90	98	81	95	100	59	45	51	41	76	61	59	30	89	59	60	58	65	34	45	42	51	57	30	16	55	53
	Honduras	54	51	54	56	88	99	90	85	100	57	44	48	57	59	91	62	24	86	40	43	40	36	45	39	27	30	57	57	45	35	46
	Bhutan	53	35	50	46	90	99	86	55	68	52	16	93	70	89	74	64	48	37	50	55	46	44	49	54	45	64	71	43	34	45	78
	Bangladesh	52	38	57	54	84	99	76	61	92	48	23	97	65	84	81	62	54	55	51	32	44	68	38	45	23	55	36	40	35	47	78
	Timor-Leste	52	39	48	38	89	98	71	77	53	33	29	72	52	70	83	54	37	48	58	46	45	51	53	58	67	51	71	60	33	40	43
	Nigeria	51	42	23	24	83	71	57	61	50	33	14	94	50	84	73	76	56	63	72	50	53	66	59	56	55	60	57	58	63	47	39
	Nepal	51	26	48	44	80	99	72	46	85	41	25	92	58	83	80	58	55	32	52	54	44	53	40	49	37	57	71	49	34	64	76
	Cambodia	51	35	56	40	81	99	77	75	89	52	30	55	48	68	77	51	38	46	45	36	39	55	42	51	67	47	66	47	21	41	45
	Sudan	50	50	37	43	80	94	64	87	68	34	20	74	70	77	76	47	44	53	33	37	47	49	46	52	73	51	58	56	33	21	41
	Marshall Islands	50	52	72	27	78	99	68	98	72	54	45	48	49	59	71	64	37	27	30	33	37	62	42	44	66	34	64	18	5	65	32
	Ghana	50	35	50	21	77	99	86	61	84	37	19	74	45	72	84	74	40	57	47	30	39	73	43	51	56	57	62	43	39	53	28
São Tomé and Príncipe	50	38	45	21	79	99	82	60	70	43	30	83	33	80	72	83	48	37	53	32	59	56	55	52	60	53	52	61	16	55	49	
Zimbabwe	49	20	28	23	72	98	75	90	52	35	22	71	27	90	79	65	71	42	64	51	50	57	59	80	50	70	37	30	19	53	43	
Kenya	49	33	35	27	75	98	76	27	61	32	28	82	26	93	86	97	68	58	79	42	31	78	39	50	48	39	48	47	64	49	50	
Equatorial Guinea	48	39	48	30	89	83	79	75	62	32	18	73	45	80	74	75	64	49	62	45	35	49	48	51	54	37	46	27	47	42	41	



Figure 2: Performance of the HAQ Index and 25 individual causes by the fourth SDI quartile (A), third SDI quartile (B), second SDI quartile (C), and first SDI quartile (D) in 2015

In addition to the HAQ Index, all causes presented in this figure are scaled 0 to 100, with 100 being the "best" value (ie, lowest observed age-standardised risk-standardised mortality rate by cause) and 0 being the "worst" value (ie, highest observed age-standardised risk-standardised mortality rate by cause) between 1990 and 2015. Within each SDI quartile, countries and geographies are ordered by their HAQ Index in 2015. HAQ Index=Healthcare Access and Quality Index. SDI=Socio-demographic Index.

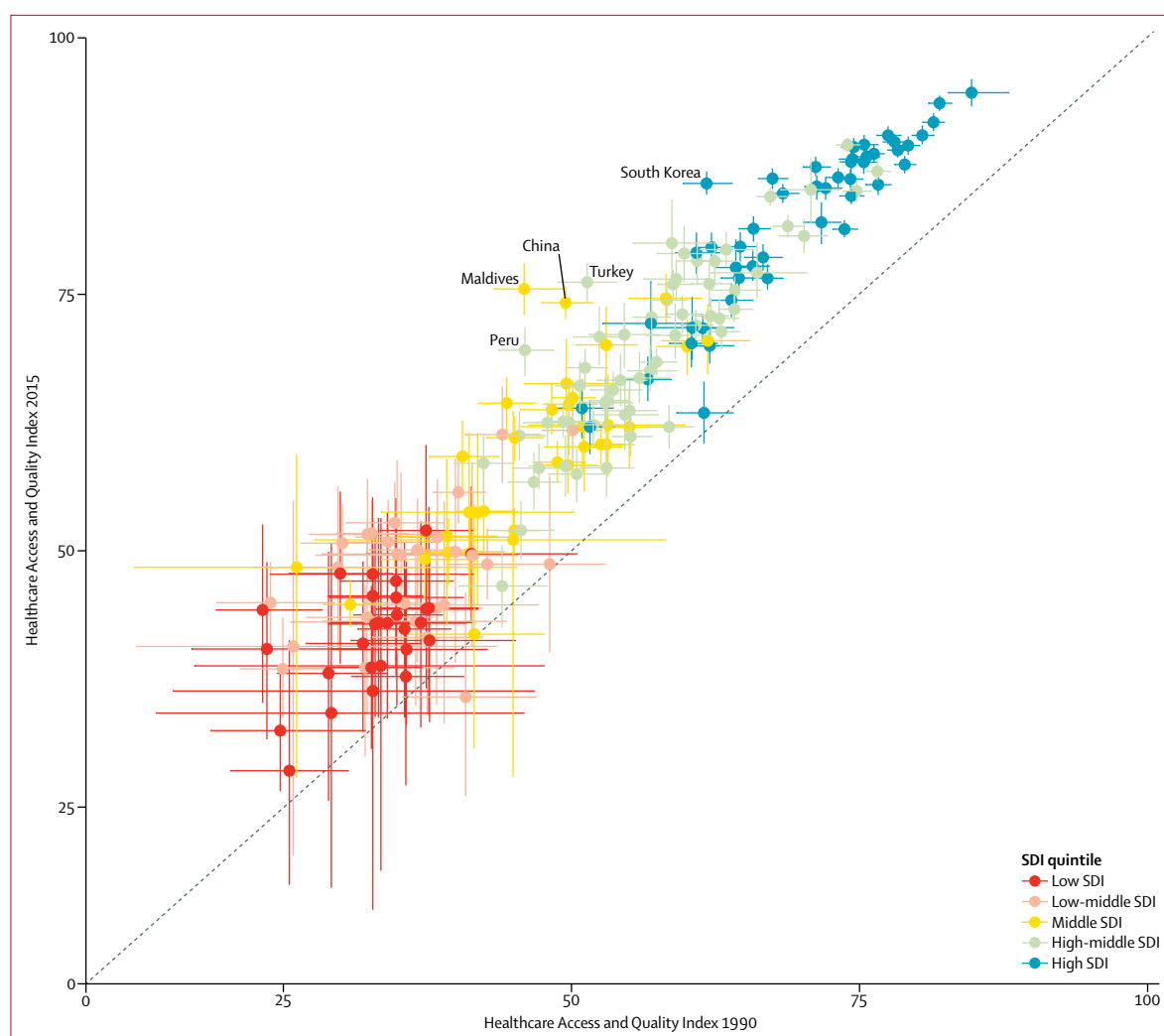


Figure 3: Comparison of 1990 and 2015 HAQ Index estimates, with uncertainty, by country or territory

Geographies with the largest improvement in the HAQ Index from 1990 to 2015 are labelled. All countries and territories are colour-coded by SDI quintile in 2015. HAQ Index=Healthcare Access and Quality Index. SDI=Socio-demographic Index.

several countries in Latin America and the Caribbean were in the first decile. By 2015, nearly all countries and territories saw increases in their HAQ Index, yet the gap between the highest and lowest HAQ Index levels was wider in 2015 (66·0) than in 1990 (61·6). The tenth decile included many countries in western Europe, Canada, Japan, and Australia, while the UK and the USA were in the ninth decile. Latin America and the Caribbean had varied HAQ Index levels, spanning from Haiti (first decile) to Chile (seventh decile). By 2015, Vietnam and Malaysia reached the sixth decile; China and Thailand rose to the seventh decile; and Turkey and several countries in the Middle East and Eastern Europe improved to the eighth decile. In sub-Saharan Africa, Cape Verde (fifth decile), Namibia, South Africa, Gabon, and Mauritania (fourth decile) had the highest HAQ Index levels in 2015, rising from their positions since 1990. At the same time, many sub-Saharan African

countries remained in the first decile in 2015, including the Democratic Republic of the Congo, Niger, and Zambia. In Asia and the Pacific, a number of countries also experienced relatively low HAQ Index levels: Afghanistan and Papua New Guinea (first decile); Pakistan and India (second decile); and Indonesia, Cambodia, and Myanmar (third decile).

Comparing the overall HAQ Index with its component parts showed substantial heterogeneity in 2015, even within similar SDI quartiles (figure 2). Within the fourth SDI quartile, most geographies performed well on several vaccine-preventable diseases, including measles, diphtheria, tetanus, and whooping cough, yet some experienced lower values for communicable conditions such as lower respiratory infections. Geographies in the fourth SDI quartile generally performed worse for cancers, but many recorded values exceeding 90 for cervical and uterine cancers. Nearly all geographies in the fourth SDI quartile

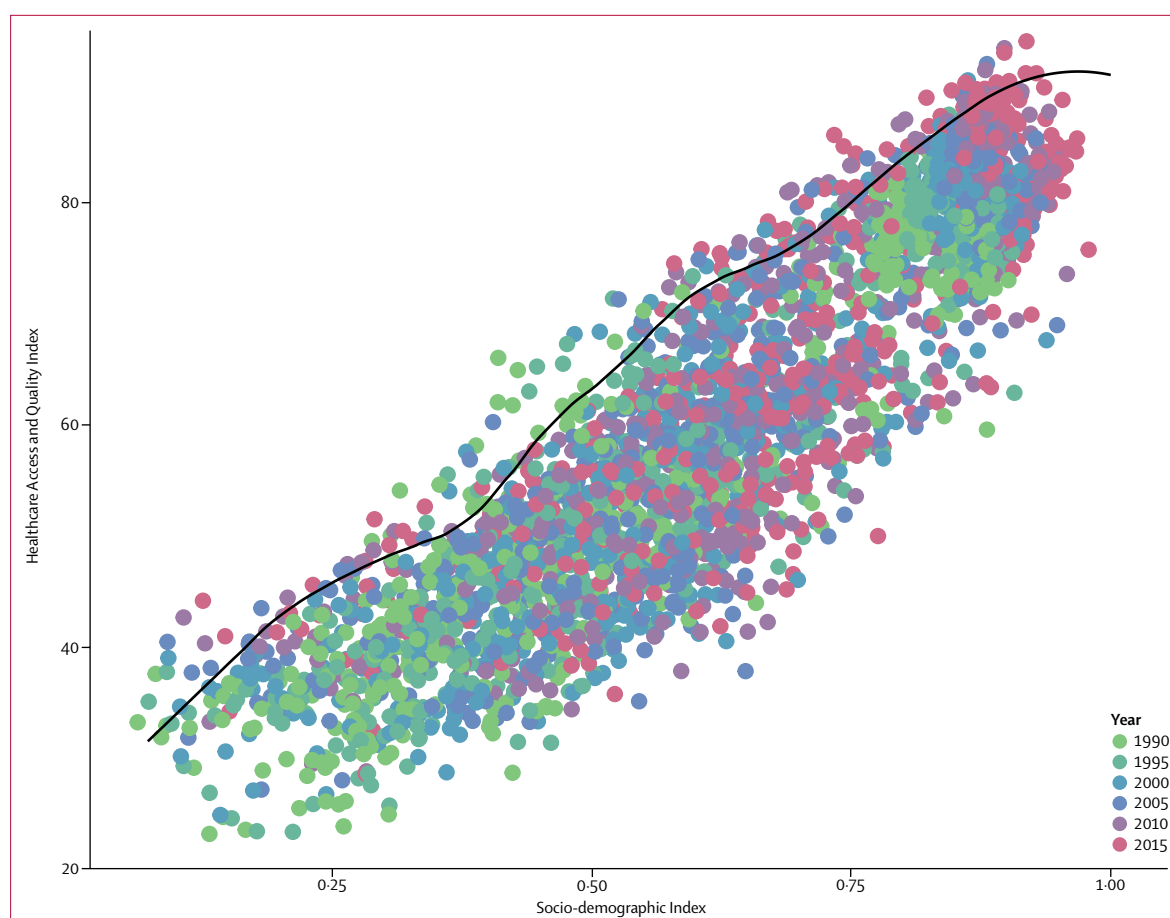


Figure 4: Defining the HAQ Index frontier on the basis of SDI

Each circle represents the HAQ Index and level of SDI for a given geography-year, and circles are colour-coded by year from 1990 to 2015. The black line represents the HAQ Index frontier, or the highest observed HAQ Index value, at a given level of SDI across years. HAQ Index=Healthcare Access and Quality Index. SDI=Socio-demographic Index.

surpassed 90 for maternal disorders, while geographies in the third and second SDI quartiles showed far more diverse results. A similar pattern emerged in causes for which routine surgeries can easily avert mortality (eg, appendicitis and hernias) among third and second SDI quartile geographies, with some countries performing fairly well for such causes (eg, China, Turkey, Sri Lanka) while others lagged behind (eg, Mexico, Indonesia, South Africa). Many geographies in the third and second SDI quartiles not only had fairly low values for NCDs such as diabetes, chronic kidney disease, and hypertensive heart disease, but also fared poorly on a subset of infectious diseases (ie, tuberculosis, lower respiratory infections, and diarrhoeal diseases) and neonatal disorders. In the first SDI quartile, neonatal and maternal disorders, tuberculosis, lower respiratory infections, and diarrhoeal diseases often led to the lowest scaled values, while most geographies experienced relatively better performances for a subset of cancers. Notably, several countries in the first SDI quartile recorded fairly high values for vaccine-preventable diseases. By contrast, nearly all of these

countries and territories saw values lower than 50 for causes associated with routine surgeries and more complex case management (eg, epilepsy, diabetes, and chronic kidney disease).

For nearly all countries and territories, the HAQ Index has markedly improved since 1990, with 167 recording statistically significant increases by 2015 (figure 3). Because of incomplete data systems, uncertainty bounds were relatively large for lower-SDI countries, whereas uncertainty for higher-SDI countries—places where data systems are more complete and of high quality—was much smaller. Five countries with the largest significant increases for the HAQ Index were South Korea (high SDI), Turkey and Peru (high-middle SDI), and China and the Maldives (middle SDI). Among low-middle-SDI and low-SDI countries, Laos and Ethiopia saw among the greatest improvements in the HAQ Index; however, these gains were less pronounced due to wide uncertainty bounds.

Based on a frontier analysis, we found that, as SDI increases, the highest observed HAQ Index values also

	HAQ Index (95% UI)						HAQ Index frontier		Difference between observed and frontier HAQ Index values	
	1990	1995	2000	2005	2010	2015	1990	2015	1990	2015
Global	40.7 39.0-42.8	42.7 41.0-44.5	44.8 43.2-46.7	47.8 46.3-49.6	51.0 49.5-52.7	53.7 52.2-55.4	61.9	73.8	21.2	20.1
Southeast Asia, east Asia, and Oceania	44.8 42.8-47.1	48.1 46.1-50.3	51.1 49.3-53.0	55.4 53.7-57.3	60.0 58.3-61.7	63.5 61.7-65.4	57.6	75.0	12.8	11.5
East Asia	49.5 47.5-51.9	53.8 51.8-55.9	57.8 56.0-59.7	63.6 61.8-65.4	69.7 68.0-71.3	73.8 72.2-75.4	57.1	75.4	7.6	1.6
China	49.5 47.4-51.8	53.7 51.7-55.9	57.8 55.9-59.7	63.7 61.9-65.6	69.9 68.2-71.5	74.2 72.5-75.8	56.2	75.4*	6.7	1.2
North Korea	53.1 46.2-59.8	55.8 49.5-61.6	56.0 50.2-61.6	57.5 52.8-62.3	60.4 56.0-64.6	62.3 57.2-67.1	70.6	69.1	17.5	6.9
Taiwan	64.2 62.5-66.4	66.8 65.1-68.8	70.1 68.5-71.9	73.6 72.1-75.4	77.1 75.6-78.6	77.6 74.7-80.4	76.8	88.6	12.6	11.0
Southeast Asia	38.6 35.8-41.4	40.9 38.4-43.4	43.0 40.7-45.4	46.0 43.7-48.5	49.4 47.1-51.8	52.1 49.5-54.7	59.0	74.0	20.4	21.9
Cambodia	30.0 26.5-33.6	31.3 28.1-34.9	34.1 30.8-37.4	40.7 37.6-44.0	45.5 42.2-48.5	50.7 47.2-54.6	45.4	62.3	15.3	11.6
Indonesia	37.2 33.4-41.4	39.7 36.3-43.7	41.3 38.3-44.5	43.8 40.9-46.7	46.8 43.7-49.9	49.2 45.3-52.9	60.6	74.4	23.4	25.2
Laos	23.8 19.1-29.3	25.7 21.5-30.4	28.7 25.0-32.7	33.6 30.4-36.9	39.6 36.4-42.8	44.9 40.7-48.9	46.3	63.9	22.5	19.0
Malaysia	54.2 52.2-56.5	57.2 55.3-59.2	60.3 58.5-62.1	63.2 61.5-64.9	63.9 62.3-65.7	66.6 64.1-69.2	69.3	81.5	15.1	14.9
Maldives	45.9 43.3-49.2	51.6 49.4-54.3	59.3 57.3-61.3	67.1 65.4-69.0	72.9 71.1-74.6	75.5 73.0-78.0	50.1	73.2*	4.3	..
Mauritius	53.6 51.6-56.1	57.3 55.6-59.1	59.8 58.2-61.8	61.8 60.1-63.5	63.3 61.6-65.1	65.7 64.0-67.5	68.6	79.0	15.0	13.3
Myanmar	29.7 22.4-37.5	31.6 23.9-39.5	34.7 26.9-43.1	39.5 31.6-48.1	44.4 36.2-52.6	48.4 40.3-56.3	45.8	64.9	16.1	16.5
Philippines	45.0 43.2-47.1	46.1 44.3-48.2	47.5 45.7-49.5	47.6 45.8-49.6	49.6 47.8-51.5	52.0 49.9-54.2	63.8	74.1	18.8	22.1
Sri Lanka	56.9 55.2-58.5	59.5 57.5-61.3	60.4 58.3-62.2	63.8 62.0-65.4	68.9 67.5-70.3	72.8 69.5-76.0	66.3	76.8	9.4	4.1
Seychelles	50.7 48.6-53.2	55.1 52.9-57.4	58.5 56.4-60.6	61.1 59.1-63.1	63.9 61.7-65.7	66.1 63.6-68.5	72.2	80.9	21.5	14.8
Thailand	52.4 50.1-54.9	55.9 53.7-58.1	59.3 57.3-61.6	64.8 62.6-67.0	68.4 66.1-70.5	70.8 68.0-73.8	66.5	76.8	14.1	5.9
Timor-Leste	32.2 27.2-39.6	35.4 30.9-41.3	38.2 33.7-45.2	42.6 38.7-48.1	48.4 44.4-53.2	51.6 46.9-57.0	46.6	59.1	14.3	7.5
Vietnam	49.5 45.8-54.0	52.4 48.8-56.9	55.8 52.7-59.2	59.6 55.4-64.2	63.0 58.5-67.7	66.3 62.1-70.6	52.2*	73.5	2.7	7.2
Oceania	33.8 28.4-39.8	34.8 29.1-40.7	35.4 29.8-41.7	36.1 30.0-42.6	37.7 31.4-43.9	40.3 33.5-46.4	51.3	62.9	17.5	22.7
American Samoa	54.6 51.8-57.5	55.6 52.4-58.6	60.2 57.7-62.8	61.7 59.0-64.2	63.1 60.5-65.7	63.3 59.8-66.7	74.0	77.4	19.4	14.1
Federated States of Micronesia	41.1 33.4-50.2	43.6 35.9-51.9	46.8 38.3-54.9	49.8 40.9-57.6	51.5 42.0-59.2	53.8 44.5-61.5	62.5	73.3	21.5	19.5
Fiji	43.9 40.1-47.8	44.1 40.6-47.7	44.7 41.7-47.7	45.0 41.9-48.1	45.4 42.0-48.9	46.6 42.5-50.6	69.2	76.1	25.3	29.6
Guam	61.5 59.1-64.0	63.6 61.3-66.0	67.0 64.9-69.2	66.4 64.1-68.5	63.7 61.4-65.9	63.4 60.5-66.5	81.7	89.8	20.2	26.3
Kiribati	35.4 31.8-39.3	36.5 33.0-40.0	39.7 36.3-43.4	41.1 37.0-44.6	43.6 39.0-47.7	44.9 40.0-49.7	53.3	61.7	17.9	16.8
Marshall Islands	41.2 37.4-45.2	43.2 39.3-47.1	43.2 39.0-48.1	44.3 40.2-48.6	46.8 42.3-51.4	49.8 45.7-54.2	56.8	71.4	15.7	21.7
Northern Mariana Islands	60.5 56.7-64.0	65.5 62.7-68.6	68.9 66.6-71.2	71.4 69.4-73.3	72.7 70.6-75.0	71.8 68.6-74.7	82.2	87.0	21.7	15.3

(Table 3 continues on next page)

	HAQ Index (95% UI)						HAQ Index frontier		Difference between observed and frontier HAQ Index values	
	1990	1995	2000	2005	2010	2015	1990	2015	1990	2015
(Continued from previous page)										
Papua New Guinea	32.0 24.9-39.7	33.0 25.7-40.7	33.4 26.2-41.6	34.0 26.5-42.7	35.8 27.7-43.7	38.6 29.9-46.6	48.7	58.8	16.7	20.2
Samoa	50.9 45.4-55.4	53.6 48.3-58.6	56.5 51.8-62.1	58.6 54.5-63.5	60.7 56.9-65.1	62.1 57.6-66.8	63.4	73.8	12.4	11.7
Solomon Islands	33.4 25.5-41.6	35.7 27.6-44.3	38.3 30.3-46.6	38.0 30.0-46.6	40.1 31.7-48.8	43.1 34.5-51.8	48.5	60.2	15.1	17.1
Tonga	55.0 50.9-58.6	56.3 53.0-59.4	57.3 54.3-60.2	58.4 55.2-61.2	60.1 56.7-63.4	62.1 58.0-65.6	63.8	73.2	8.8	11.1
Vanuatu	36.4 28.3-44.3	37.4 28.5-46.3	38.3 30.0-47.4	38.4 30.4-46.1	41.1 32.7-49.0	43.1 34.9-50.2	52.8	66.4	16.3	23.2
Central Europe, eastern Europe, and central Asia	57.5 56.2-59.0	55.9 54.5-57.5	58.4 57.1-60.0	60.8 59.4-62.4	65.4 64.1-66.8	68.5 67.3-69.9	76.7	85.3	19.2	16.7
Central Asia	50.7 49.2-52.5	49.2 47.6-51.0	50.7 48.9-52.6	52.4 50.8-54.3	56.6 55.0-58.4	59.9 58.4-61.6	72.3	78.2	21.6	18.3
Armenia	56.8 54.8-59.1	55.6 53.5-58.0	59.0 56.9-61.5	60.0 57.9-62.6	63.7 61.7-66.2	67.5 65.5-70.0	71.7	80.6	14.9	13.1
Azerbaijan	52.9 50.8-55.1	51.8 49.7-54.0	53.6 51.4-55.6	55.4 53.5-57.5	59.9 57.9-62.1	64.5 62.6-66.5	74.0	83.3	21.1	18.8
Georgia	58.4 56.4-60.6	60.2 58.0-62.2	60.9 58.4-63.0	60.7 58.7-62.6	60.8 58.8-62.9	62.1 60.0-64.2	76.1	81.1	17.7	19.1
Kazakhstan	55.1 53.5-56.9	49.9 48.2-51.9	51.3 49.6-53.3	51.9 50.1-54.0	57.9 56.3-59.8	61.1 59.2-63.3	75.5	84.7	20.4	23.6
Kyrgyzstan	52.5 50.6-54.5	51.7 49.8-53.9	52.4 50.6-54.5	54.6 52.6-56.6	57.7 55.9-59.6	60.4 58.4-62.2	71.5	73.6	19.0	13.2
Mongolia	42.3 39.8-45.0	42.1 39.7-44.9	44.7 42.3-47.4	50.9 47.6-53.5	54.9 51.1-57.4	58.5 54.8-61.2	64.4	76.8	22.1	18.3
Tajikistan	48.7 46.8-51.2	48.1 45.8-50.3	48.6 46.4-51.2	51.7 49.7-54.1	55.4 53.4-57.8	58.6 56.7-60.7	63.8	70.0	15.1	11.4
Turkmenistan	47.1 44.8-49.5	47.7 45.4-50.1	48.8 46.5-51.1	51.1 48.8-53.7	54.5 52.4-57.0	58.1 56.0-60.4	71.7	82.6	24.6	24.6
Uzbekistan	51.9 49.9-54.1	51.7 49.5-53.9	54.0 51.9-56.2	56.1 53.9-58.4	59.2 57.1-61.6	62.3 60.2-64.5	67.1	76.5	15.3	14.2
Central Europe	60.6 59.3-62.2	63.4 62.1-64.8	67.5 66.2-68.8	70.5 69.3-71.8	73.8 72.6-74.9	77.1 76.0-78.2	76.2	86.4	15.6	9.3
Albania	62.4 60.6-64.2	65.1 63.3-67.0	68.5 66.7-70.4	71.6 69.7-73.4	75.3 73.1-77.2	78.2 76.0-80.2	69.7	79.1*	7.3	0.9
Bosnia and Herzegovina	60.9 59.2-62.9	62.1 60.4-64.0	68.8 67.1-70.5	72.1 70.2-73.6	75.3 73.0-76.9	78.2 75.9-79.9	62.5*	79.3*	1.6	1.0
Bulgaria	63.0 61.7-64.5	63.2 61.9-64.7	64.8 63.5-66.3	66.7 65.3-68.2	67.9 66.4-69.3	71.4 69.6-73.1	76.6	84.8	13.6	13.5
Croatia	68.8 67.5-70.0	70.4 69.2-71.8	73.4 72.2-74.6	76.8 75.6-77.9	78.9 77.9-80.0	81.6 80.5-82.7	75.0	82.9	6.2	1.2
Czech Republic	68.3 67.1-69.7	73.2 72.1-74.3	77.1 75.8-78.1	79.2 78.0-80.3	81.8 80.9-82.8	84.8 83.9-85.7	83.0	90.2	14.7	5.3
Hungary	64.6 63.4-66.0	67.2 66.0-68.5	71.0 69.9-72.2	73.7 72.6-74.8	76.1 75.1-77.2	79.6 78.2-81.0	78.4	87.6	13.8	8.0
Macedonia	61.9 60.3-63.9	63.4 61.9-65.3	67.0 65.7-68.5	69.9 68.4-71.3	74.2 72.7-75.5	76.0 73.8-78.0	74.1	81.1	12.2	5.1
Montenegro	70.2 68.0-72.2	70.2 68.7-71.9	69.9 68.3-71.4	74.4 73.0-75.8	78.2 76.9-79.6	80.7 79.0-82.3	75.8	84.0	5.6	3.3
Poland	62.1 60.8-63.6	65.4 64.2-66.8	70.8 69.5-72.0	73.8 72.4-75.0	76.3 75.1-77.5	79.6 78.2-81.0	76.8	88.8	14.7	9.2
Romania	58.3 56.8-60.0	60.0 58.6-61.6	64.2 62.8-65.7	67.2 65.6-68.6	71.1 69.7-72.5	74.4 72.7-76.0	76.1	84.0	17.8	9.6

(Table 3 continues on next page)

	HAQ Index (95% UI)						HAQ Index frontier		Difference between observed and frontier HAQ Index values	
	1990	1995	2000	2005	2010	2015	1990	2015	1990	2015
(Continued from previous page)										
Serbia	64.2 62.1-66.4	64.4 62.8-66.3	66.6 65.1-68.3	69.4 67.9-71.0	73.1 71.8-74.3	75.4 74.2-76.7	74.4	81.9	10.2	6.5
Slovakia	66.6 65.0-68.2	69.4 67.8-70.9	70.8 69.2-72.2	72.2 70.7-73.6	74.9 73.6-76.2	78.6 77.3-79.9	77.3	88.5	10.7	9.9
Slovenia	71.2 70.1-72.4	72.8 71.6-74.2	76.4 75.3-77.5	79.8 78.8-80.8	84.3 83.4-85.3	87.4 86.5-88.4	80.4	88.0*	9.2	0.6
Eastern Europe	61.7 60.4-63.1	58.2 56.7-59.8	60.4 59.0-62.0	63.4 61.9-65.0	68.9 67.7-70.2	71.9 70.6-73.2	79.4	87.2	17.7	15.3
Belarus	63.9 62.1-65.7	63.2 61.4-65.1	65.6 63.4-67.4	68.0 66.0-69.7	71.7 70.2-73.3	74.4 72.8-76.1	75.8	87.4	11.9	13.0
Estonia	65.8 64.5-67.2	62.5 61.0-64.1	67.4 66.0-68.9	71.4 70.1-72.8	77.5 76.4-78.6	81.4 80.1-82.6	77.3	88.3	11.5	6.9
Latvia	65.7 64.5-67.1	62.4 61.0-64.0	68.7 67.5-70.1	70.7 69.4-72.0	74.4 73.2-75.7	77.7 76.3-79.3	79.0	88.4	13.2	10.6
Lithuania	67.0 65.8-68.3	64.2 62.8-65.6	69.6 68.5-71.0	70.2 69.0-71.6	73.6 72.5-74.9	76.6 75.5-77.9	77.6	87.0	10.6	10.4
Moldova	59.6 58.1-61.4	56.0 54.3-57.9	60.8 59.0-62.5	64.8 62.9-66.7	66.8 65.1-68.4	73.1 71.2-74.9	72.8	76.7	13.2	3.6
Russia	61.4 60.0-62.9	57.6 56.1-59.4	59.7 58.3-61.3	62.9 61.4-64.6	68.5 67.1-69.9	71.7 70.3-73.1	81.1	88.1	19.8	16.4
Ukraine	62.8 61.3-64.5	59.4 57.8-61.2	62.0 60.6-63.8	64.4 62.9-66.1	70.5 69.2-72.0	72.7 70.8-74.5	76.7	85.0	13.9	12.4
High-income	71.1 70.2-72.2	74.6 73.6-75.6	77.2 76.3-78.2	79.6 78.8-80.5	81.6 80.8-82.4	83.1 82.3-83.8	83.3	90.0	12.2	7.0
High-income Asia Pacific	72.6 71.3-73.8	77.2 76.2-78.3	79.8 78.8-80.8	83.3 82.4-84.2	86.0 85.2-86.8	87.4 86.7-88.2	82.6	90.0	10.0	2.6
Brunei	62.0 60.1-64.0	64.3 62.4-66.2	66.7 65.1-68.6	68.6 67.0-70.3	69.5 68.0-71.2	70.0 68.3-71.8	83.0	91.3	21.0	21.3
Japan	78.3 77.4-79.2	80.7 79.8-81.6	82.9 82.1-83.7	85.6 84.9-86.3	87.8 87.2-88.6	89.0 88.3-89.8	84.5	90.4	6.2	1.3
South Korea	61.7 59.6-63.9	70.5 69.0-72.2	74.6 73.4-76.0	80.4 79.3-81.6	83.9 82.9-84.9	85.8 84.7-87.0	77.3	89.0	15.6	3.2
Singapore	67.4 66.2-68.8	72.8 71.6-74.1	77.3 76.2-78.5	80.8 79.8-81.9	84.2 83.3-85.1	86.3 85.3-87.3	77.3	89.6	9.9	3.3
Australasia	77.2 76.2-78.2	80.1 79.2-81.1	82.9 82.1-83.8	85.3 84.6-86.1	87.4 86.7-88.1	89.1 88.4-89.8	84.5	90.8	7.3	1.7
Australia	78.0 77.0-79.1	80.8 79.8-81.8	83.7 82.9-84.6	86.2 85.4-86.9	88.2 87.5-88.9	89.8 89.1-90.6	84.7	91.0	6.7	1.1
New Zealand	74.2 73.2-75.2	77.6 76.6-78.6	80.0 79.2-80.9	82.5 81.7-83.4	84.2 83.4-85.0	86.2 85.4-87.2	83.4	89.9	9.2	3.6
Western Europe	73.2 72.3-74.2	76.8 76.0-77.8	79.9 79.0-80.8	82.9 82.1-83.7	84.9 84.2-85.6	86.8 86.0-87.5	80.9	88.8	7.7	2.1
Andorra	84.7 82.7-87.9	88.0 86.0-92.2	91.1 89.4-93.5	92.6 91.1-94.4	94.0 92.5-95.5	94.6 93.3-96.0	85.8*	91.2*	1.1	..
Austria	74.4 73.2-75.5	78.2 77.1-79.2	81.6 80.7-82.5	84.2 83.4-85.0	86.1 85.3-86.9	88.2 87.3-89.0	83.2	90.0	8.8	1.8
Belgium	75.4 74.3-76.6	78.8 77.9-79.8	81.6 80.6-82.6	84.6 83.6-85.4	86.3 85.4-87.1	87.9 86.8-88.8	82.6	89.6	7.2	1.8
Cyprus	72.0 70.6-73.5	73.4 72.2-74.7	76.4 75.0-77.5	79.2 78.1-80.3	82.6 81.6-83.7	85.3 84.2-86.4	78.2	89.5	6.1	4.2
Denmark	76.6 75.5-77.7	77.2 76.1-78.2	79.5 78.4-80.5	81.9 81.0-82.8	83.6 82.7-84.6	85.7 84.7-86.7	85.6	90.9	9.0	5.2
Finland	75.4 74.3-76.6	78.8 77.8-79.9	82.0 81.0-82.9	84.5 83.5-85.3	87.2 86.4-88.1	89.6 88.6-90.5	83.0	90.2*	7.6	0.6
France	74.3 73.2-75.4	77.5 76.5-78.5	80.3 79.4-81.3	84.2 83.4-85.1	85.7 84.9-86.5	87.9 86.9-88.9	79.0	86.7*	4.8	..

(Table 3 continues on next page)

	HAQ Index (95% UI)						HAQ Index frontier		Difference between observed and frontier HAQ Index values	
	1990	1995	2000	2005	2010	2015	1990	2015	1990	2015
(Continued from previous page)										
Germany	73.1 72.0-74.3	77.1 76.1-78.2	80.6 79.4-81.6	83.2 82.0-84.1	84.9 83.9-85.7	86.4 85.4-87.3	83.5	90.6	10.4	4.3
Greece	76.5 75.6-77.6	79.5 78.7-80.5	82.2 81.4-83.0	84.4 83.6-85.2	85.2 84.4-86.0	87.0 86.1-87.9	77.0*	85.9*	0.5	..
Iceland	81.9 81.0-83.0	84.2 83.3-85.2	87.1 86.1-88.0	89.8 88.9-90.6	92.1 91.2-92.8	93.6 92.9-94.4	83.1	90.3*	1.2	..
Ireland	75.6 74.5-76.7	78.4 77.3-79.5	79.6 78.5-80.7	83.5 82.6-84.4	86.0 85.2-86.9	88.4 87.5-89.3	79.0	90.0	3.3	1.6
Israel	71.3 70.2-72.5	74.3 73.2-75.3	77.5 76.2-78.6	80.3 79.0-81.4	83.7 82.5-84.6	85.5 84.2-86.5	80.3	87.1	9.0	1.6
Italy	76.2 75.3-77.2	79.1 78.2-80.0	82.5 81.7-83.4	85.5 84.7-86.3	87.5 86.8-88.2	88.7 87.8-89.6	81.8	88.1*	5.5	..
Luxembourg	74.5 73.4-75.7	78.8 77.9-79.9	82.2 81.3-83.1	84.9 84.1-85.8	87.5 86.6-88.3	89.3 88.4-90.2	83.6	90.9	9.1	1.6
Malta	74.7 73.5-76.0	76.8 75.6-78.0	78.9 77.8-80.1	81.4 80.3-82.6	82.9 81.8-83.9	85.1 84.0-86.1	74.9*	84.5*	0.1	..
Netherlands	79.2 78.2-80.2	80.8 79.7-81.8	82.1 81.0-83.1	85.1 84.1-86.0	88.2 87.4-88.9	89.5 88.6-90.4	83.2	90.3*	4.0	0.8
Norway	77.5 76.5-78.6	81.0 80.1-82.0	82.8 81.8-83.7	85.9 85.1-86.8	88.0 87.2-88.9	90.5 89.6-91.4	85.9	91.6	8.4	1.1
Portugal	67.2 66.1-68.6	71.5 70.4-72.7	74.7 73.7-75.8	79.7 78.7-80.7	81.9 81.1-82.9	84.5 83.6-85.5	71.4	80.5*	4.1	..
Spain	73.9 73.0-75.0	78.1 77.3-79.0	81.4 80.6-82.3	84.1 83.4-84.9	87.2 86.5-87.8	89.6 88.8-90.3	74.7*	85.7*	0.8	..
Sweden	80.4 79.5-81.4	83.9 83.0-84.8	85.7 84.9-86.6	87.0 86.2-87.9	88.7 87.9-89.7	90.5 89.6-91.4	82.9	90.2*	2.4	..
Switzerland	81.4 80.5-82.3	83.4 82.6-84.3	85.4 84.7-86.2	88.2 87.5-88.9	90.1 89.5-90.8	91.8 90.9-92.6	86.4	91.4*	5.0	..
UK	74.3 73.2-75.3	76.6 75.7-77.6	78.4 77.5-79.3	80.6 79.8-81.4	82.7 82.0-83.5	84.6 83.8-85.4	83.4	90.3	9.2	5.7
Southern Latin America	57.6 56.3-59.3	61.1 59.8-62.6	64.7 63.3-66.1	66.7 65.4-68.1	68.1 66.9-69.4	70.0 68.8-71.3	73.4	82.6	15.7	12.5
Argentina	57.4 56.0-59.1	60.3 59.0-61.9	63.5 62.1-65.0	65.3 64.0-66.8	66.6 65.3-67.9	68.4 67.1-69.7	73.3	81.9	15.9	13.5
Chile	58.8 57.4-60.4	64.2 62.7-65.6	69.2 67.7-70.5	72.0 70.5-73.3	73.9 72.6-75.1	76.0 74.5-77.4	73.8	84.5	15.0	8.5
Uruguay	60.8 59.4-62.2	63.1 61.9-64.6	67.1 65.7-68.4	68.7 67.4-70.0	70.6 69.2-71.9	72.0 70.5-73.5	72.5	79.7	11.7	7.7
High-income North America	74.0 73.0-75.1	76.3 75.3-77.3	78.1 77.3-79.0	79.2 78.3-80.1	80.9 80.1-81.7	81.8 81.0-82.7	88.5	91.5	14.4	9.7
Canada	78.9 78.0-79.9	80.7 79.8-81.6	83.2 82.2-84.0	84.7 83.9-85.5	86.3 85.5-87.1	87.6 86.8-88.5	88.1	91.6	9.2	4.0
Greenland	59.0 56.5-62.0	62.3 59.8-65.2	64.3 62.0-67.5	65.8 63.5-68.9	68.1 66.0-71.3	71.0 68.7-74.1	72.5	81.0	13.6	10.0
USA	73.7 72.7-74.8	76.0 75.0-77.0	77.8 76.9-78.7	78.8 77.9-79.7	80.5 79.6-81.3	81.3 80.5-82.2	88.5	91.5	14.8	10.2
Latin America and Caribbean	46.5 44.9-48.5	50.8 49.2-52.6	54.6 53.0-56.4	57.4 55.8-59.1	59.6 58.0-61.3	61.9 60.4-63.5	65.4	75.3	18.9	13.4
Caribbean	42.4 40.2-44.9	45.9 43.9-48.1	48.8 46.6-51.0	50.8 48.6-53.3	52.3 49.9-54.7	54.5 51.9-57.2	68.5	74.9	26.1	20.4
Antigua and Barbuda	56.6 54.6-58.7	57.8 55.9-59.9	60.3 58.4-62.5	62.5 60.5-64.6	64.9 63.0-66.9	66.7 64.6-68.9	79.2	87.0	22.6	20.3
The Bahamas	50.9 48.2-53.6	54.1 51.7-56.6	57.0 54.6-59.4	59.9 57.5-62.2	62.1 59.7-64.5	63.9 61.0-66.7	77.9	86.6	27.0	22.7
Barbados	55.9 53.7-58.4	59.5 57.5-61.9	62.6 60.5-64.8	64.3 62.4-66.1	65.5 63.6-67.5	66.8 64.4-69.3	75.6	82.8	19.7	16.0

(Table 3 continues on next page)

	HAQ Index (95% UI)						HAQ Index frontier		Difference between observed and frontier HAQ Index values	
	1990	1995	2000	2005	2010	2015	1990	2015	1990	2015
(Continued from previous page)										
Belize	49.7 47.3-52.2	50.5 48.2-53.1	50.6 48.1-53.2	53.7 51.3-56.4	56.3 53.9-58.7	58.3 55.6-61.3	61.4	74.8	11.7	16.5
Bermuda	60.8 58.9-62.8	64.8 62.9-66.6	71.6 69.7-73.5	74.1 72.4-75.8	77.0 75.2-78.6	79.0 77.0-81.0	86.9	91.1	26.0	12.1
Cuba	64.1 62.7-65.7	65.2 63.9-66.8	67.7 66.4-69.0	70.5 69.3-71.8	72.1 71.0-73.4	73.5 72.3-74.9	74.8	81.5	10.7	7.9
Dominica	53.0 50.7-55.4	54.6 52.3-57.0	57.7 55.5-59.9	59.0 56.8-61.3	58.5 56.1-60.8	58.1 55.2-61.0	72.0	80.4	19.0	22.3
Dominican Republic	47.9 45.8-50.2	52.2 50.1-54.4	56.6 54.4-58.7	58.6 56.4-60.5	60.8 58.5-62.6	62.5 60.2-64.5	64.1	75.6	16.2	13.1
Grenada	49.4 46.3-52.5	52.8 50.3-55.4	54.0 51.5-56.5	55.1 52.5-57.5	57.0 54.5-59.6	58.3 55.2-61.2	67.3	80.5	17.9	22.2
Guyana	39.3 36.9-42.0	41.3 38.9-44.1	42.5 39.9-45.1	44.7 42.2-47.8	47.0 44.2-50.0	49.8 46.7-53.2	62.7	74.4	23.4	24.6
Haiti	24.9 21.2-28.9	29.2 25.7-33.1	32.7 29.0-36.8	34.8 30.4-39.0	35.9 31.5-40.3	38.5 33.7-43.5	48.2	54.6	23.3	16.1
Jamaica	55.0 52.6-57.4	58.0 55.5-60.5	59.5 56.8-61.9	62.2 59.1-64.8	62.9 59.7-65.5	63.7 60.1-66.5	71.2	77.7	16.2	14.1
Puerto Rico	64.5 62.9-66.2	66.1 64.7-67.6	69.8 68.6-71.3	72.6 71.3-73.9	74.0 72.9-75.3	76.6 75.1-78.1	81.7	89.6	17.2	13.0
Saint Lucia	49.7 47.1-52.5	53.0 50.8-55.4	56.0 53.9-58.2	58.5 56.2-60.7	61.1 58.7-63.5	62.5 59.3-65.4	69.9	79.4	20.2	16.9
Saint Vincent and the Grenadines	50.4 47.9-53.1	51.4 49.0-53.7	53.0 50.8-55.3	55.2 53.2-57.6	56.7 54.5-59.0	57.5 54.7-60.2	71.0	80.0	20.5	22.5
Suriname	46.7 44.4-49.0	48.6 46.2-51.0	49.5 47.2-52.1	51.0 48.4-53.5	53.5 51.0-56.0	56.7 53.9-59.5	67.5	76.7	20.8	20.0
Trinidad and Tobago	51.6 49.6-53.7	53.5 51.5-55.6	55.8 53.8-57.8	58.6 56.7-60.7	60.5 58.4-62.6	62.1 59.4-64.6	75.5	86.4	23.9	24.4
Virgin Islands, USA	60.4 58.5-62.6	63.1 61.3-65.1	65.8 63.9-67.7	68.8 66.9-70.6	69.8 67.7-71.7	70.2 67.9-72.4	81.2	89.9	20.8	19.7
Andean Latin America	43.2 41.2-45.6	47.0 45.1-49.3	53.5 51.5-55.5	58.1 56.1-60.1	60.9 59.1-62.9	64.1 62.1-65.9	64.9	75.6	21.7	11.5
Bolivia	40.5 37.6-43.6	43.8 41.2-46.8	48.5 46.2-51.2	53.3 50.7-55.8	56.4 53.5-59.2	59.2 55.9-62.7	56.6	72.6	16.1	13.4
Ecuador	45.4 43.5-47.7	48.7 46.8-50.9	53.5 51.3-55.6	56.1 53.9-58.3	58.6 56.3-60.7	61.2 58.8-63.6	66.2	75.7	20.8	14.5
Peru	45.9 43.6-48.4	49.8 47.5-52.2	57.1 54.8-59.3	62.7 60.5-64.7	65.9 63.7-67.9	69.6 67.0-71.8	66.7	76.8	20.8	7.2
Central Latin America	47.6 45.9-49.6	52.2 50.5-54.1	55.8 54.1-57.5	58.3 56.5-59.9	60.2 58.5-61.9	62.4 60.8-64.1	66.6	76.1	19.0	13.7
Colombia	51.1 49.5-53.2	54.9 53.3-56.6	58.4 56.8-60.1	61.6 59.9-63.2	64.4 62.5-66.2	67.8 65.8-69.7	67.1	76.5	16.0	8.6
Costa Rica	62.1 60.4-63.6	62.8 61.1-64.4	65.4 63.8-67.1	68.6 67.0-70.1	70.8 69.1-72.3	72.9 70.9-74.6	68.6	78.0	6.5	5.1
El Salvador	44.3 41.9-46.8	49.0 46.8-51.3	55.3 53.1-57.6	59.6 56.8-61.8	62.2 58.8-64.6	64.4 61.2-66.9	57.2	73.0	12.9	8.6
Guatemala	40.1 37.9-42.5	44.4 42.3-46.8	48.7 46.6-51.0	51.3 48.9-53.5	53.2 50.8-55.5	55.7 52.7-58.8	50.7	66.9	10.6	11.2
Honduras	42.3 40.0-44.8	45.7 42.9-48.6	47.6 43.8-51.2	49.5 45.3-53.4	51.8 47.7-56.0	53.9 49.9-57.8	51.5	69.5	9.1	15.6
Mexico	49.2 47.6-51.2	54.1 52.4-55.9	57.4 55.6-59.1	59.1 57.4-60.7	60.5 58.9-62.1	62.6 61.0-64.2	68.9	77.6	19.7	15.1
Nicaragua	49.7 47.5-52.1	51.7 49.7-53.8	55.5 53.4-57.6	58.8 56.5-60.9	61.8 59.3-63.9	64.3 61.8-66.7	53.1	68.9	3.4	4.7

(Table 3 continues on next page)

	HAQ Index (95% UI)						HAQ Index frontier		Difference between observed and frontier HAQ Index values	
	1990	1995	2000	2005	2010	2015	1990	2015	1990	2015
(Continued from previous page)										
Panama	52.9 50.7-55.2	56.7 54.6-58.7	59.8 57.6-61.8	61.3 58.9-63.5	62.2 59.7-64.3	64.4 61.4-67.0	71.6	79.9	18.7	15.5
Venezuela	53.1 51.4-54.9	55.6 53.8-57.5	59.3 57.5-61.0	62.3 60.7-64.0	64.2 62.5-65.8	64.7 62.2-66.9	71.4	78.5	18.3	13.8
Tropical Latin America	50.1 48.3-52.0	53.7 52.0-55.6	56.9 55.3-58.7	59.8 58.3-61.4	62.5 61.0-64.1	64.7 63.2-66.5	63.7	74.7	13.7	10.0
Brazil	50.1 48.3-52.0	53.8 52.0-55.6	57.0 55.4-58.7	59.9 58.4-61.6	62.6 61.2-64.3	64.9 63.4-66.7	63.8	74.7	13.8	9.8
Paraguay	53.0 50.7-55.4	55.1 52.9-57.5	56.6 54.0-58.9	57.4 54.8-59.9	58.6 56.1-61.0	60.4 57.4-63.2	61.7	74.0	8.7	13.6
North Africa and Middle East	43.8 41.9-46.0	46.5 44.5-48.6	49.9 48.0-51.9	52.8 51.0-54.8	55.7 53.9-57.7	58.4 56.5-60.5	55.7	72.3	11.9	13.8
Afghanistan	24.7 18.6-32.0	24.5 18.5-31.6	24.8 18.7-31.7	27.1 21.2-33.5	29.4 23.5-35.7	32.5 26.6-38.6	38.0	47.6	13.3	15.1
Algeria	48.2 45.5-51.1	52.6 49.9-55.2	56.2 53.7-58.7	59.6 57.3-62.1	62.2 59.9-64.3	63.7 61.3-66.3	58.3	71.4	10.1	7.6
Bahrain	59.7 57.4-62.2	63.2 60.6-65.6	67.3 64.9-69.7	71.3 69.0-73.4	77.2 75.1-79.1	79.0 76.2-81.7	71.8	82.3	12.1	3.3
Egypt	45.0 42.5-47.5	49.3 47.1-51.7	54.4 52.4-56.4	56.9 54.8-58.7	58.2 56.2-60.1	61.0 58.7-63.1	58.0	73.0	12.9	12.0
Iran	54.6 51.5-57.6	59.6 56.5-62.3	63.5 60.9-65.6	65.7 62.6-68.6	68.9 65.4-72.3	71.1 67.9-74.2	60.0	77.5	5.4	6.4
Iraq	51.1 47.5-54.4	50.7 47.4-54.0	51.8 48.4-55.0	54.4 50.4-58.0	57.2 53.2-61.3	60.1 55.8-64.3	53.2*	70.1	2.1	10.0
Jordan	59.1 56.2-61.9	62.0 59.2-64.8	65.0 62.6-67.3	68.4 66.4-70.3	74.3 72.8-75.8	76.5 74.4-78.4	63.1	76.3*	4.0	..
Kuwait	71.7 70.1-73.3	71.4 70.0-72.8	74.9 73.6-76.1	75.7 74.5-77.0	77.7 76.4-78.9	82.0 79.9-84.0	76.0	88.5	4.3	6.4
Lebanon	58.7 55.3-62.2	63.4 60.1-66.5	68.5 65.2-71.7	73.1 69.7-76.4	77.0 73.4-80.9	80.0 76.0-84.3	69.5	80.5*	10.9	0.6
Libya	60.0 57.3-62.8	63.7 61.2-66.4	65.4 63.1-67.8	67.1 64.9-69.3	69.7 67.4-72.0	69.9 67.2-72.6	61.5*	74.0	1.4	4.1
Morocco	44.0 40.7-47.3	47.8 44.7-51.1	52.6 49.2-56.0	55.6 51.4-59.1	58.7 54.1-62.8	61.3 56.6-66.0	49.4	63.0*	5.4	1.7
Palestine	61.8 57.8-65.5	65.6 62.3-68.6	68.3 66.2-70.4	68.7 66.6-70.5	69.0 66.3-71.5	70.5 67.2-74.1	55.8*	69.4*
Oman	66.1 62.0-70.4	71.4 67.6-74.9	74.4 71.3-77.0	76.2 74.2-78.0	72.9 71.0-75.1	77.1 74.6-80.1	54.3*	78.6*	..	1.5
Qatar	70.8 68.1-73.3	71.3 68.8-73.8	73.1 70.9-75.6	77.5 75.0-79.7	83.1 80.7-85.3	85.2 82.0-88.3	72.9*	84.5*	2.1	..
Saudi Arabia	63.4 61.1-65.8	66.8 64.8-68.8	71.2 69.6-72.7	74.2 72.8-75.6	77.0 75.6-78.4	79.4 77.7-81.1	65.4*	81.0*	2.0	1.6
Sudan	36.6 32.4-41.0	38.8 34.1-43.2	42.0 37.2-46.7	44.9 40.1-49.6	47.4 42.6-52.5	50.1 45.0-55.1	46.6	56.4	10.0	6.4
Syria	58.2 54.9-61.2	63.1 59.5-66.2	68.2 65.3-70.7	71.4 69.0-73.4	73.8 71.9-75.5	74.6 72.1-77.0	52.1*	70.4*
Tunisia	53.0 50.3-55.7	56.9 54.2-59.4	61.4 59.0-64.0	64.5 61.6-67.4	67.4 64.3-70.7	70.1 66.6-73.8	59.1	74.3	6.1	4.3
Turkey	51.3 48.8-53.9	55.4 53.0-57.8	62.4 60.3-64.4	68.6 66.7-70.6	74.3 72.4-75.9	76.2 74.3-78.1	65.2	75.9*	13.9	..
United Arab Emirates	56.9 52.7-61.0	60.8 57.3-64.3	64.7 61.9-67.8	69.0 66.7-71.3	71.4 68.1-74.6	72.2 68.0-76.3	73.7	89.2	16.8	17.1
Yemen	35.2 27.7-43.5	38.0 30.3-46.6	41.3 32.8-50.0	44.5 36.1-53.3	47.8 38.8-56.0	49.6 40.4-57.6	37.0*	54.1*	1.8	4.5

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	HAQ Index (95% UI)						HAQ Index frontier		Difference between observed and frontier HAQ Index values	
	1990	1995	2000	2005	2010	2015	1990	2015	1990	2015
(Continued from previous page)										
South Asia	30.7	32.9	35.1	38.1	41.1	44.4	48.5	66.3	17.7	21.9
	28.5-33.3	30.8-35.2	32.9-37.6	36.0-40.5	39.0-43.4	42.3-46.7				
Bangladesh	32.6	35.8	39.6	44.3	48.7	51.7	47.0	61.1	14.4	9.4
	29.5-35.7	32.8-38.8	36.8-42.4	41.7-47.2	46.1-51.4	48.4-54.9				
Bhutan	34.6	37.6	42.3	46.2	50.1	52.7	47.3	65.9	12.7	13.2
	30.4-38.8	33.9-41.7	38.6-45.8	42.4-49.8	46.4-53.9	48.5-56.7				
India	30.7	33.1	35.3	38.2	41.2	44.8	48.8	68.4	18.0	23.6
	28.4-33.5	30.8-35.6	32.9-37.9	36.0-40.7	38.9-43.6	42.6-47.2				
Nepal	34.0	37.1	41.6	45.7	48.2	50.8	44.4	55.7	10.4	4.9
	30.2-38.1	33.8-40.5	38.6-44.6	42.3-49.1	44.2-52.1	46.7-55.0				
Pakistan	36.5	35.6	36.3	38.1	41.2	43.1	47.2	60.7	10.6	17.7
	33.3-40.3	32.2-39.3	32.9-40.1	34.9-41.9	37.5-45.1	39.2-47.1				
Sub-Saharan Africa	32.3	33.5	34.6	37.4	40.5	42.2	46.6	52.3	14.3	10.1
	29.7-35.2	31.2-36.1	32.4-36.9	35.3-39.7	38.4-42.9	39.6-44.9				
Central sub-Saharan Africa	31.1	32.1	33.0	35.7	37.2	38.6	45.7	48.1	14.6	9.5
	25.9-36.8	27.0-37.4	27.8-37.8	30.0-41.0	30.9-42.7	31.8-45.6				
Angola	25.8	28.1	31.2	35.6	37.7	40.7	46.1	55.3	20.3	14.6
	12.2-43.4	12.9-45.2	15.3-47.8	18.3-51.1	18.7-52.1	20.3-54.9				
Central African Republic	25.5	25.8	26.7	28.0	28.8	28.6	44.0	47.3	18.6	18.7
	20.3-30.6	19.1-33.9	18.2-37.7	18.3-39.8	18.6-40.9	17.4-41.3				
Congo (Brazzaville)	32.2	31.4	33.3	39.3	41.2	43.5	53.6	65.5	21.4	22.0
	26.9-38.0	26.8-36.4	28.7-38.4	34.4-44.5	34.9-47.1	34.2-52.7				
DR Congo	35.6	36.1	36.2	38.1	39.3	40.4	44.7	45.2*	9.1	4.8
	29.2-42.6	30.7-41.5	31.1-41.0	33.0-43.0	33.8-44.8	33.1-49.0				
Equatorial Guinea	26.1	27.5	35.4	42.9	45.6	48.4	46.4	72.5	20.4	24.1
	12.0-45.2	12.5-46.7	17.5-50.6	23.0-55.3	25.6-57.1	27.9-59.4				
Gabon	39.1	40.1	41.8	44.1	48.4	51.4	61.1	74.0	22.0	22.6
	34.9-43.4	36.1-44.4	37.1-46.3	39.1-48.9	42.3-54.2	42.7-59.0				
Eastern sub-Saharan Africa	29.6	31.2	33.8	37.5	40.5	42.4	43.1	49.9	13.5	7.5
	27.1-32.7	28.6-34.1	31.3-36.6	35.0-40.1	37.4-43.6	38.6-46.2				
Burundi	23.5	23.4	27.0	35.5	40.5	40.4	39.9	45.3*	16.4	4.9
	17.0-31.9	18.3-29.1	22.3-31.7	30.5-40.3	34.2-47.3	31.6-48.9				
Comoros	32.7	34.3	38.4	44.1	47.2	47.7	46.0	50.5*	13.3	2.8
	23.7-41.6	27.9-40.1	33.8-42.9	39.2-48.8	41.6-52.5	39.6-55.2				
Djibouti	38.9	38.8	39.4	40.9	43.2	44.7	48.9	60.2	10.0	15.4
	30.8-47.1	29.0-48.0	28.6-50.4	29.7-51.4	31.3-54.1	33.1-54.8				
Eritrea	28.9	35.3	38.0	38.8	37.8	38.1	41.5	48.9*	12.7	10.9
	24.4-33.9	29.8-41.2	29.2-47.1	27.6-49.5	26.4-48.5	25.6-49.9				
Ethiopia	23.1	26.8	30.6	34.9	40.4	44.2	36.8	48.1*	13.7	3.9
	19.1-28.2	22.8-31.5	26.3-35.8	30.9-39.6	34.3-47.0	35.2-52.6				
Kenya	42.6	42.3	44.0	46.4	47.5	48.7	49.5	61.1	6.8	12.4
	39.3-45.6	39.1-45.7	40.7-47.4	43.1-49.6	44.3-50.6	45.2-52.2				
Madagascar	34.8	36.5	38.7	41.6	42.5	43.7	46.4	50.8*	11.6	7.1
	31.0-38.7	32.6-43.3	34.1-47.3	36.5-49.4	35.5-50.3	34.9-53.1				
Malawi	34.7	35.4	36.5	40.6	44.3	47.0	42.4	48.4*	7.7	1.4
	29.9-39.6	28.8-42.4	29.1-43.1	34.1-46.8	37.8-50.5	38.4-55.1				
Mozambique	33.2	35.1	36.4	39.6	40.9	43.0	31.5*	47.1*	..	4.1
	29.0-37.5	30.9-39.3	31.4-41.8	33.4-46.2	33.9-48.9	33.7-53.2				
Rwanda	29.9	23.3	30.4	42.6	47.0	47.8	43.3	51.0*	13.4	3.2
	25.4-34.4	18.5-27.7	25.4-35.0	37.4-47.9	40.4-53.6	39.0-55.8				
Somalia	29.1	29.3	30.1	31.8	33.3	34.2	35.5*	38.6*	6.4	4.4
	13.9-45.8	14.8-46.3	14.9-47.3	15.9-49.6	16.0-50.0	17.2-50.8				
South Sudan	33.4	34.7	37.5	39.0	38.8	38.8	38.0*	46.4*	4.6	7.6
	17.2-47.6	18.0-49.6	19.8-52.3	20.5-53.5	17.9-53.6	18.8-53.2				

(Table 3 continues on next page)

	HAQ Index (95% UI)						HAQ Index frontier		Difference between observed and frontier HAQ Index values	
	1990	1995	2000	2005	2010	2015	1990	2015	1990	2015
(Continued from previous page)										
Tanzania	39.9 36.0-44.1	41.0 36.7-45.6	43.1 38.0-48.3	46.7 40.2-52.3	48.8 39.9-56.5	49.9 39.0-59.0	47.0	54.6*	7.2	4.6
Uganda	34.0 28.8-40.9	33.9 28.1-41.4	35.2 30.2-41.2	38.2 33.6-43.3	41.4 34.9-48.6	42.9 33.6-53.7	43.2	51.3*	9.2	8.3
Zambia	37.4 32.6-42.2	34.6 29.6-39.9	34.3 29.4-39.0	35.5 31.1-40.2	37.4 32.2-42.6	41.6 33.9-50.1	49.0	60.7	11.6	19.2
Southern sub-Saharan Africa	44.8 42.2-47.3	46.7 44.0-49.2	43.4 40.6-46.2	43.1 40.2-46.1	46.3 43.5-49.1	49.2 46.6-51.9	65.3	74.8	20.5	25.6
Botswana	44.9 27.6-58.1	45.4 24.3-59.3	43.7 20.5-59.4	43.9 21.8-60.3	48.6 26.0-62.5	51.1 28.0-63.6	55.4*	73.9	10.5	22.9
Lesotho	40.8 35.3-46.9	41.8 36.4-48.4	39.4 33.0-45.2	33.2 27.9-38.4	34.4 27.4-41.6	35.7 26.1-45.9	49.1	65.1	8.4	29.3
Namibia	41.8 38.1-45.6	41.9 37.9-45.7	39.9 34.6-45.2	43.5 37.3-49.2	50.4 43.8-57.3	53.7 44.7-61.5	58.0	72.9	16.2	19.2
South Africa	45.6 42.7-48.4	47.9 45.4-50.4	44.8 41.8-48.1	45.2 41.6-48.7	49.4 46.0-52.8	52.0 49.2-54.9	69.7	77.1	24.1	25.1
Swaziland	41.5 35.7-47.6	45.7 38.7-54.2	40.7 33.3-47.5	35.1 27.8-42.1	37.8 28.9-47.8	41.9 30.7-54.5	55.0	73.3	13.5	31.4
Zimbabwe	48.1 43.8-52.9	49.5 41.1-57.0	45.4 36.8-52.2	41.8 34.4-48.6	42.1 35.8-48.2	48.7 40.1-57.3	56.0	66.6	7.9	17.9
Western sub-Saharan Africa	35.3 31.3-39.3	36.2 33.1-39.4	37.0 34.3-40.2	39.7 36.9-42.7	43.3 40.2-46.3	44.8 40.9-48.1	46.2	53.3	10.9	8.5
Benin	36.9 32.9-41.2	37.0 32.8-41.3	37.3 32.7-42.2	40.4 34.5-46.5	41.5 33.0-49.9	43.0 32.8-52.9	42.8	49.7*	5.9	6.7
Burkina Faso	32.9 28.9-37.4	34.1 29.8-38.7	36.0 31.6-40.7	40.3 35.4-45.2	42.7 36.2-49.4	42.9 33.8-51.5	33.1*	45.2*	0.2	2.3
Cameroon	38.3 34.6-42.2	37.7 33.5-41.8	37.2 32.3-42.6	41.0 36.1-46.4	42.5 35.6-49.1	44.4 35.0-53.3	48.9	60.4	10.6	16.0
Cape Verde	50.1 47.4-52.6	49.3 45.3-53.2	50.8 45.5-56.2	53.7 49.2-58.4	57.9 55.6-60.3	61.7 58.1-64.9	48.3*	67.6	..	5.8
Chad	35.6 30.8-40.6	35.2 30.8-40.3	32.1 27.1-37.4	34.1 26.9-41.1	36.3 26.8-46.1	37.7 27.1-48.2	38.1*	47.5*	2.5	9.8
Côte d'Ivoire	35.5 31.4-39.4	33.2 28.5-38.3	34.4 29.2-39.7	37.6 32.4-42.5	40.7 34.2-47.2	42.4 33.7-50.8	46.3	51.5	10.8	9.2
The Gambia	41.3 32.1-50.4	42.4 35.2-49.7	43.3 38.6-48.2	45.6 41.6-50.1	47.7 43.2-52.5	49.7 43.1-56.3	45.2*	49.0*	4.0	..
Ghana	34.8 28.3-40.9	38.5 33.9-43.3	40.3 35.4-45.5	44.2 38.5-50.4	47.3 38.8-55.7	49.7 40.0-58.8	49.8	64.2	15.0	14.6
Guinea	32.6 28.6-36.9	33.6 29.6-37.9	34.0 30.1-38.3	37.0 32.6-41.5	37.6 32.6-43.0	38.6 30.7-46.6	40.4	47.1	7.8	8.5
Guinea-Bissau	32.7 15.3-46.7	33.1 14.7-47.3	33.6 15.7-48.2	33.3 14.9-48.3	35.1 16.2-49.1	36.3 15.0-50.2	40.8*	47.8*	8.1	11.5
Liberia	34.7 28.9-40.5	37.1 32.3-41.9	39.5 34.7-44.7	41.7 37.0-46.7	43.2 38.2-48.5	45.4 37.8-52.9	43.9	47.3*	9.2	1.9
Mali	32.7 28.8-37.0	33.8 29.9-37.9	37.7 33.7-42.0	43.5 39.2-47.8	44.4 39.2-49.9	45.6 38.1-53.2	35.1*	44.8*	2.4	..
Mauritania	37.3 33.3-41.4	38.9 34.8-43.5	42.9 38.5-47.8	46.9 42.1-52.7	49.6 43.5-55.4	52.0 43.8-60.3	46.6	53.4*	9.2	1.4
Niger	31.8 26.9-36.9	33.1 28.6-37.9	34.6 30.3-38.9	37.7 33.2-42.3	40.3 34.7-45.5	41.0 32.3-48.9	32.6*	38.2*	0.8	..
Nigeria	38.3 31.2-45.4	39.7 34.4-45.0	40.6 36.2-45.4	43.1 38.4-47.9	48.8 43.2-54.4	51.3 43.2-57.0	48.2	61.4	9.9	10.1
São Tomé and Príncipe	41.3 37.8-45.2	41.9 38.0-45.7	42.8 39.3-46.8	44.0 39.3-48.4	47.3 40.9-53.7	49.6 40.7-58.6	48.1	58.8	6.8	9.2

(Table 3 continues on next page)

	HAQ Index (95% UI)						HAQ Index frontier		Difference between observed and frontier HAQ Index values	
	1990	1995	2000	2005	2010	2015	1990	2015	1990	2015
(Continued from previous page)										
Senegal	37.6 33.3–41.8	38.1 34.0–42.2	38.9 34.8–43.0	41.5 35.7–47.1	42.9 34.4–51.2	44.4 34.0–54.3	43.5	49.4*	6.0	4.9
Sierra Leone	37.6 30.8–45.1	37.2 32.1–42.8	35.4 30.7–40.4	36.1 31.8–40.8	38.2 33.1–43.7	41.3 33.3–49.1	41.3*	48.9*	3.6	7.6
Togo	37.4 33.0–41.8	36.9 32.8–41.3	36.9 32.1–42.6	40.1 34.8–45.6	41.8 36.1–47.9	44.3 36.6–52.5	45.5	50.3*	8.2	6.0

Geographies that exceed the HAQ Index frontier associated with their level of SDI have double dots in place of values in the columns representing the difference between observed and frontier HAQ Index levels. GBD=Global Burden of Disease. HAQ Index=Healthcare Access and Quality Index. SDI=Socio-demographic Index. UI=Uncertainty interval. *Geographies for which the HAQ Index frontier in 1990 or 2015 is within the 95% UIs of their observed HAQ Index values for those years.

Table 3: Global, regional, and national or territory-level estimates of the HAQ Index for each 5-year interval from 1990 to 2015, frontier values in 1990 and 2015 on the basis of SDI, and the difference between observed HAQ Index and frontier values in 1990 and 2015

rose (figure 4). Further, maximum HAQ Index levels achieved generally improved since 1990 across levels of SDI. Table 3 details each geography's HAQ Index values for 5-year intervals from 1990 to 2015, as well as their frontier HAQ Index levels on the basis of a location's SDI. Measuring the distance between a geography's observed HAQ Index in 1990 and 2015 and its frontier for these years provides a benchmark for potential gains in health-care access and quality—a metric that also considers the geography's relative resources on the basis of SDI. Additionally, comparing how differences between a given place's observed HAQ Index and frontier change over time can show where personal health-care access and quality have improved in parallel with changes in development.

Worldwide, the average HAQ Index values significantly increased, but the average global frontier improved in tandem; subsequently, gaps between the global HAQ Index and frontier changed minimally between 1990 and 2015. While most regions recorded narrowing gaps between average HAQ Index values and maximum levels achieved, a subset saw negligible progress or widening differences (eg, southern sub-Saharan Africa, south Asia, and the Middle East). In 2015, 52 countries and territories had HAQ Index estimates that included the frontier within their uncertainty bounds, indicating these geographies met the maximum levels of personal health-care access and quality attained by locations of similar SDI. Conversely, 62 geographies fell further behind the HAQ Index frontier associated with their level of SDI; this trend was especially pronounced in much of southern sub-Saharan Africa, Iraq, Pakistan, and Honduras (figure 5). This result was in stark contrast with several countries in eastern and western sub-Saharan Africa (eg, Burundi, Comoros, Rwanda), Turkey, Peru, and South Korea, many of which more than halved the differences between their HAQ Index and frontiers given their SDI by 2015.

Discussion

Drawing from GBD 2015, we constructed a novel measure of personal health-care access and quality—the HAQ Index—by using highly standardised estimates of 32 different causes that are amenable to personal health care. Compared with previous efforts, the HAQ Index provides a clearer signal on personal health-care access and quality over time and place because GBD provides enhanced comparability of cause of death data, helps to account for variation due to behavioural and environmental risk factors, and includes 195 countries and territories over time. Our analysis showed large differences in personal health-care access and quality, spanning from a low of 23.1 in Ethiopia in 1990 to higher than 90 in Andorra, Iceland, Switzerland, Norway, and Sweden in 2015. The global HAQ Index improved from 40.7 in 1990 to 53.7 in 2015, and 167 of 195 countries and territories significantly increased their HAQ Index during this time. Although the HAQ Index and SDI were highly correlated, we noted substantial heterogeneity for geographies at similar SDI. If every location reached the highest observed HAQ Index experienced by level of SDI, our global measure of health-care access and quality could have reached 73.8 in 2015—a clear indicator of untapped potential for health-care improvement worldwide.

While most countries saw progress on the HAQ Index since 1990, the marked improvements recorded for countries including South Korea, Turkey, and China highlight that much more rapid advances are possible. A subset of countries narrowed the gap between observed personal health-care access and quality and what could be expected given their level of development—and then achieved gains beyond what might be anticipated on the basis of SDI. Peru, the Maldives, and Ethiopia are examples of such stand-out geographies for reaching higher-than-expected levels of personal health care and access since 1990. Case studies conducted by the World Bank highlight potential drivers of these countries' successes,⁶⁰ and additional research on how certain

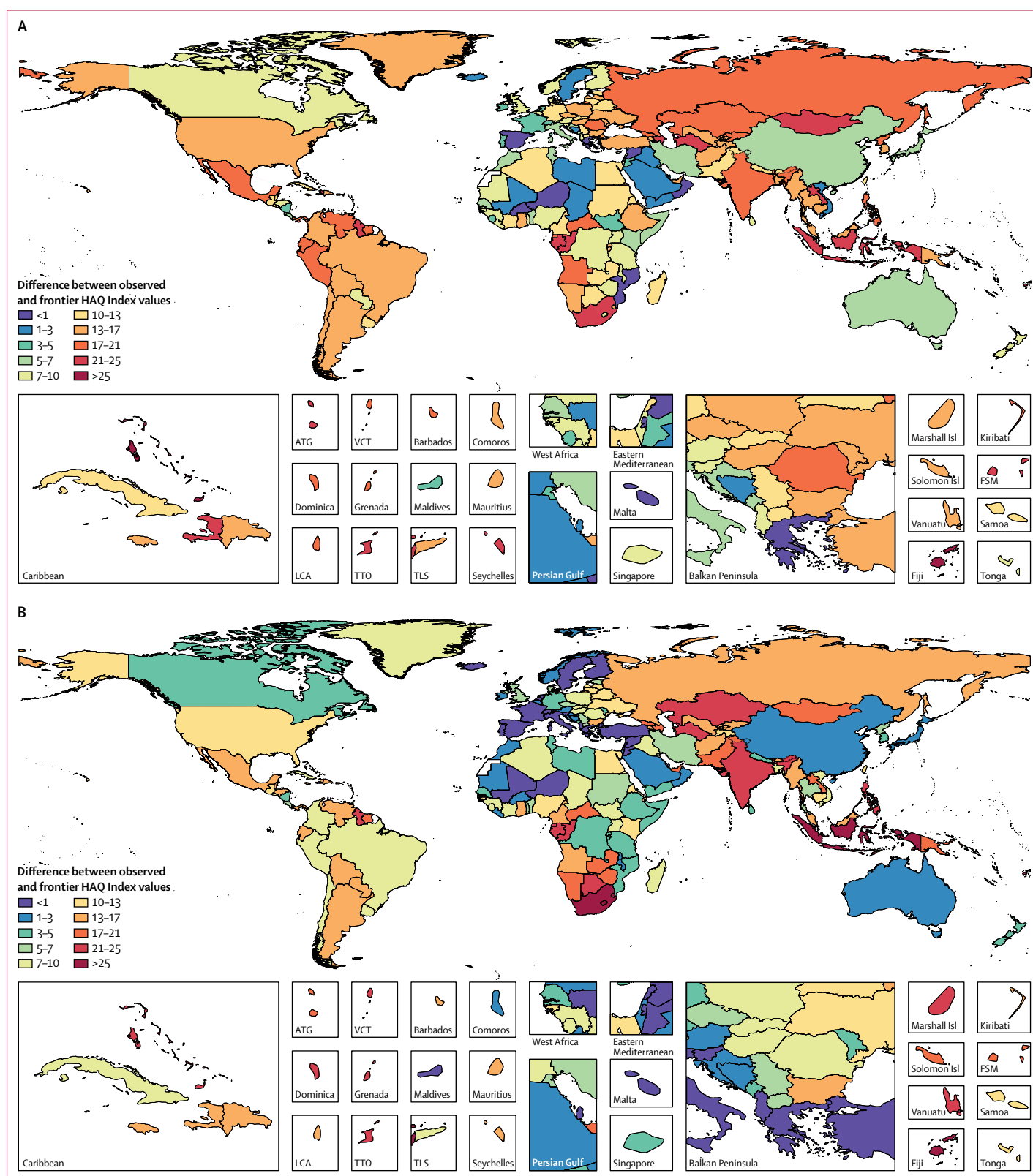


Figure 5: Map of the gap between observed HAQ Index and frontier values in 1990 (A) and 2015 (B)

Difference in observed HAQ Index and frontier values were the highest levels achieved by geographies of similar SDI in a given year. HAQ Index=Healthcare Access and Quality Index.

SDI=Socio-demographic Index. ATG=Antigua and Barbuda. VCT=Saint Vincent and the Grenadines. LCA=Saint Lucia. TTO=Trinidad and Tobago. TLS=Timor-Leste. FSM=Federated States of Micronesia.

health-system attributes, including financing arrangements, provider ownership, and stewardship functions, are related to personal health-care access and quality is warranted. Separating out measures of access from quality of care received would be ideal, especially because programmatic and policy options to address barriers in access and quality can differ across and within countries. Nonetheless, such information measured in a consistent manner is rarely available.^{34,46,57,60}

Several geographies had minimal gains in reducing the difference between their observed HAQ Index and the highest levels achieved at a similar SDI—a warning sign that heightened health-care access and quality is not an inevitable product of increased development. Further, a subset of countries in southern sub-Saharan Africa, south Asia, and the Middle East saw widening gaps between HAQ Index values in 2015 and the frontier reached by countries of comparable SDI. These findings could reflect several challenges faced by these countries, including subnational inequalities in both wealth and health-care options; and recent or rapid epidemiological transitions wherein the health-care sector and cause-specific services offered trail behind the diseases afflicting populations. Along with examining the drivers of greater-than-expected gains, future studies should strive to understand why other countries are lagging behind—and how they can pursue advancing health-care access and quality for all individuals.

Improving personal health-care access and quality is an important priority in the SDG era, emphasising the potential utility of the HAQ Index for SDG monitoring. At present, the UHC target—SDG 3.8—focuses mainly on so-called tracer interventions in the areas of maternal and child health, reproductive health, and a subset of infectious diseases,⁶¹ and thus fails to adequately capture the vital role of personal health care for NCDs and injuries. The HAQ Index provides a more comprehensive measure that reflects health-system capacity for effectively detecting risk for, managing, and preventing early death from a range of conditions. Combining the HAQ Index, coverage of health interventions, and prevalence of risk factors that are modifiable through public health initiatives could provide a more robust mechanism for tracking UHC progress across multiple dimensions of health-system action.

Health systems can provide differential access and quality across therapeutic areas and levels of care. The HAQ Index reflects the average experience as captured by included conditions, and does not currently distinguish between diseases more strongly related to primary or secondary care. Our PCA weights suggest some conditions are less highly correlated with other causes, including colon cancer, breast cancer, testicular cancer, non-melanoma skin cancer, or diphtheria. The comparatively low weights on these outcomes could reflect measurement error, residual challenges in risk standardisation, or health-system heterogeneity by level

of care. Subnational work that identifies variation in personal health-care access and quality within a particular health-system structure, and that uses multi-method approaches to view the health system from the perspective of patients and frontline providers,^{62,63} may help elucidate whether some health-system components function distinctly from its average. For example, access to and quality of oncology care might be relatively distinct from other health-system dimensions and, where appropriate treatment is contingent on specialists or particular equipment, such as radiotherapy for cancer, even a temporary loss of these resources may substantially affect outcomes.⁶⁴ Conversely, access to high-quality primary care services, which enable early detection of conditions that are fatal if diagnosed at later stages, can be shaped by different factors, such as flexibility of clinic hours or types of insurance providers accepted.⁶⁵

Mortality amenable to personal health care and mortality attributable to modifiable behavioural and environmental risk factors

For the present study, we based the HAQ Index on the list of causes established by Nolte and McKee,^{4,9,11,30,31,35} and did not systematically re-examine scientific literature to update causes for which personal health care can significantly improve outcomes. Conducting this kind of systematic review is crucial to identifying additional causes for inclusion in the HAQ Index. Numerous causes should be considered, and would likely result in adding antiretroviral therapy for HIV, artemisinin-based combination therapies for malaria, treatment of hepatitis C, and improvements in emergency and trauma care, among others.^{41,42,66–69} Expanding the amenable cause list should be determined by clear criteria that define when health care sufficiently reduces cause-specific mortality and thus provides a strong enough signal about access and quality. Such additions will probably improve the HAQ Index, though the nature of PCA estimation and its measurement of common variance across 32 causes may not substantially change future results. This analysis stemmed from existing scientific literature on mortality amenable to health care, but personal health care also can have profound effects on non-fatal health outcomes (eg, hip replacement for osteoarthritis or surgery for cataracts). Future updates of the HAQ Index should consider incorporating measures of non-fatal conditions amenable to personal health care, which would then capture health-system capacity to deliver health gains through improved functional health status.

Understanding how much mortality or disease burden is avertable based on providing access to high-quality personal health care and modifying behavioural and environmental risks through public health initiatives is of high policy interest. GBD currently assesses mortality and burden attributable to a large set of risk factors, which supplies useful insights on the potential of risk modification to improve health. Quantification of the full potential of personal health care to reduce burden

by cause would provide an important additional piece of policy-relevant information. Controlling for other factors through statistical modelling, such as income and educational attainment, we could examine how much cause-specific variation relates to the HAQ Index. Such work would help to pinpoint opportunities for national and subnational progress through health-system improvements, which would likely include public health programmes and policies as well as the organisation and delivery of personal health services across levels of care.

Moving to performance measurement

In estimating the HAQ Index frontier by SDI,⁵⁸ we quantified the gap between observed personal health-care access and quality and levels potentially achievable at a given level of SDI. With these analyses, we lay the foundation for a refined assessment of health-system performance. The World Health Report 2000, which sought to evaluate health-system performance by country,⁷⁰ estimated the contribution of health systems for improving healthy life expectancy while statistically controlling for other factors. As suggested by Nolte and McKee,^{9,71} using a measure more directly related to health-system actions, such as mortality amenable to personal health care, could reduce the need to control for other factors in health-system performance assessment. The World Health Report 2000 framework used five broad dimensions—average levels of health, inequalities in health, average levels of health-system performance, inequalities in responsiveness, and fair financing—and then compared overall health system attainment based on a frontier for health expenditure per capita.⁷¹ Our current analysis only focused on the contribution of personal health care to mortality and the potential for improvement in this domain relative to development. In the future, GBD could support examining subnational health inequalities and expanding into health finance quantification of financial risk protection. A stronger empirical basis for assessing these three domains of health-system performance would also facilitate testing a range of efficiency and performance models.

Our frontier analysis showed that the highest observed HAQ Index levels, as achieved by geographies with an SDI of 0·8 or higher, steadily shifted higher over time. This expansion of health-care access and quality may reflect a rising share of GDP allocated to health among high-SDI countries. However, the frontier estimate for GDP per capita spent on health points to a similar shift upward at high expenditure. One explanation of this trend is new medical technologies and programmes, which could be driving an overall upward shift in health-care access and quality achievable in well financed systems. Another potential explanation is innovation in health-care organisation, such as the creation of centralised stroke care units in major cities.⁷² A more detailed examination of these changes may further elucidate how investing in medical innovations can affect health-system performance.

In particular, this might shed light on the association between investment in health-care resources and outcomes, a relationship that is unlikely to be linear. For instance, audits have identified three main factors underlying maternal deaths: substandard care, delays in care, and problems with blood transfusions.⁷³ Addressing the latter requires a different type of intervention, namely investments in infrastructure, than the former two factors. Such knowledge is of particular importance in the SDG era, as some studies point to advances in medical technology and innovation as the primary pathway for elevating health alongside increasing development.⁷⁴

HAQ Index compared to other measures of access and quality of care

Detailed results on HAQ Index components seem consistent with previous, albeit limited, studies on health-care performance. Within Europe, Nordic countries performed especially well, corresponding with past work on a composite measure of public health policies.⁷⁵ Country performance on diabetes aligned with earlier work on diabetes mortality and incidence,²⁵ wherein country-level differences were largely explained by known health-system changes, such as substantial improvements in several Baltic states during the late 1990s. In Latin America, Costa Rica's relatively high HAQ Index (72·9), as compared with nearby countries (eg, Nicaragua [64·3], Guatemala [55·7]), is consistent with its designation as an original "good health at low cost" country.⁷⁶

In view of the paucity of standard health-care access and quality measures, assessing HAQ Index validity compared to other indicators was challenging. In this analysis, we identified three measures of health-system resources and three measures of intervention coverage that included at least 70 countries. These correlations, which all exceeded 0·60, offer some evidence of convergent validity but do not provide criterion validity.^{77,78} Nonetheless, these results are encouraging and stand in contrast to previous studies done in limited settings.^{37–40} In comparison with past work,^{9,11,31} the moderately high correlation with other health-care indicators might be due to our efforts to risk-standardise mortality amenable to health care; PCA weighting of different amenable conditions; and the inclusion of a substantively larger, more diverse set of health systems across the development spectrum. Additional validation analyses are needed to compare HAQ Index performance with other measures of health-care access and quality; such validation exercises might be more feasible at the subnational level with greater data density, such as states in the USA.⁷⁹

Limitations

This analysis has a number of limitations beyond those already described. First, many limitations experienced in GBD cause of death estimation are applicable to this study.⁴⁷ Second, our risk-standardisation procedure might not represent all possible risk-outcome pairs as they

pertain to included causes of amenable mortality (eg, determinants of testicular cancer or neonatal disorders).⁴⁸ With its annual updates, GBD aims to improve upon its comparative risk assessment, and thus HAQ Index assessment is likely to be improved alongside advances in risk quantification. Third, two causes received negative weights in the PCA analysis and were subsequently excluded. One potential explanation for this is that joint PAFs for these causes may underestimate risk-attributable mortality in high-SDI countries (eg, the effects of diet, obesity, and physical inactivity for breast cancer). However, given the high Spearman's rank order correlation between the average of all 32 causes and the HAQ Index, excluding these causes from the PCA likely had minimal effect on our results. Fourth, we used PCA to construct the HAQ Index based on age-standardised risk-standardised death rates from the 32 causes. Alternative methods for index construction led to highly correlated results, but exact rankings somewhat varied. We subsequently view exact rank orders as less useful than comparing a given geography's HAQ Index values over time, to countries of similar SDI, and relative to the HAQ Index frontier. Fifth, while the HAQ Index offers a more robust indicator of overall health-care access and quality than currently available measures, it does not directly capture effects of personal health care on causes without substantial mortality (eg, depression, hip osteoarthritis, and cataracts). The effects of health care on both fatal and non-fatal conditions may be highly correlated, but incorporating how access and quality of care explicitly affect non-fatal outcomes would improve measurement. Sixth, GBD corrections for cause of death misclassifications (so-called garbage codes) varies substantially by geography and thus can affect results. Even among high-SDI countries, GBD showed substantial variation for the proportion of amenable deaths assigned to garbage codes, ranging from 7.9% in Finland to 39.8% in Portugal (appendix p 19). Seventh, for countries with complete or nearly complete vital registration (VR) data and few deaths misclassified based on ICD codes, the HAQ Index may be more robust and less prone to high levels of uncertainty than for countries with lower-quality or non-existent VR data. Mortality estimates that heavily draw from verbal autopsy data or other modelling approaches have larger UIs. Our results for most of sub-Saharan Africa, for example, include wide UIs and thus few countries recorded HAQ Index values that statistically differed from the regional mean. Eighth, we rescale the log age-standardised risk-standardised death rate for each cause from 0 to 100 using the observed range across countries from 1990 to 2015, but achieving 100 does not mean that additional improvement is not possible. Subsequently, the HAQ Index range reported here is relative to national achievements to date, and these thresholds may rise if or when improved personal health-care access and quality occurs for given causes. Ninth, the HAQ Index does not currently capture subnational inequalities in personal health-care access and

quality, which might emerge on the basis of geographic location or socioeconomic status, among other factors. Future efforts to quantify these measures with greater geospatial resolution should be prioritised.

Conclusions

Our analysis demonstrates that a policy-relevant summary measure of personal health-care access and quality can be derived from GBD. This novel measure supports the first-ever comparable assessment of personal health-care access and quality across 195 countries and territories, over time, and along the development spectrum. The HAQ Index considerably advances previous efforts to approximate personal health-care access and quality by systematically adjusting for cause of death certification biases and misclassification, risk-standardising death rates across geographies, and applying PCA to identify common dimensions of health-care access and quality associated with multiple conditions. Globally, most countries and territories recorded gains in personal health-care access and quality from 1990 to 2015, yet many still experienced levels that fell well below what has been achieved by geographies at a similar development status. Amid calls to improve monitoring of UHC and overall health-system performance, the HAQ Index provides a strong basis for benchmarking progress toward greater access and higher-quality personal health care alongside country-level gains in resources to achieve these aims.

GBD 2015 Healthcare Access and Quality Collaborators

Ryan M Barber, Nancy Fullman, Reed J D Sorensen, Thomas Bollyky, Martin McKee, Ellen Nolte, Amanuel Alemu Abajobir, Kalkidan Hassen Abate, Cristiana Abbafati, Kaja M Abbas, Foad Abd-Allah, Abdishakur M Abdulle, Ahmed Abdulahi Abdurahaman, Semaw Ferede Abera, Biju Abraham, Girmatsion Fisseha Abreha, Kelemework Adane, Ademola Lukman Adelekan, Ifedayo Morayo O Adetifa, Ashkan Afshin, Arnab Agarwal, Sanjay Kumar Agarwal, Sunilkumar Agarwal, Anurag Agrawal, Aliasghar Ahmad Kiadaliri, Alireza Ahmadi, Kedir Yimam Ahmed, Muktar Beshir Ahmed, Rufus Olusola Akinyemi, Tomi F Akinyemiju, Nadia Akseer, Ziyad Al-Aly, Khurshid Alam, Noore Alam, Sayed Saidul Alam, Zewdie Aderaw Alemu, Kefyalew Addis Alene, Lily Alexander, Raghbi Ali, Syed Danish Ali, Reza Alizadeh-Navaei, Ala'a Alkerwi, François Alla, Peter Allebeck, Christine Allen, Rajaa Al-Raddadi, Ubai Alsharif, Khalid A Altirkawi, Elena Alvarez Martin, Nelson Alvis-Guzman, Azmeraw T Amare, Erfan Amini, Walid Ammar, Joshu Amo-Adjei, Yaw Ampem Amoako, Benjamin O Anderson, Sofia Androudi, Hossein Ansari, Mustafa Geleto Ansha, Carl Abelardo T Antonio, Johan Årnlöv, Al Artaman, Hamid Asayesh, Reza Assadi, Ayalew Astatkie, Tesfay Mehari Atey, Suleman Atique, Niguse Tadele Atnafu, Sachin R Atre, Leticia Avila-Burgos, Euripide Frinel G Arthur Avokpaho, Beatriz Paulina Ayala Quintanilla, Ashish Awasthi, Nebiyu Negussu Ayele, Peter Azzopardi, Huda Omer Ba Saleem, Till Bärnighausen, Umar Bacha, Alaa Badawi, Amitava Banerjee, Aleksandra Barac, Miguel A Barboza, Suzanne L Barker-Collo, Lope H Barrero, Sanjay Basu, Bernhard T Baune, Kaleab Baye, Yibeltal Tebekaw Bayou, Shahrzad Bazargan-Hejazi, Neeraj Bedi, Ettore Beghi, Yannick Béjot, Aminu K Bello, Derrick A Bennett, Isabela M Bensenor, Adugnaw Berhane, Eduardo Bernabé, Oscar Alberto Bernal, Addisu Shunu Beyene, Tariku Jibat Beyene, Zulfiqar A Bhutta, Sibhatu Biadgilign, Boris Bikbov, Sait Montes Birlik, Charles Birungi, Stan Biryukov, Donal Bisanzio, Habtamu Mellie Bizuayehu, Dipan Bose, Michael Brainin,

- Michael Brauer, Alexandra Brazinova, Nicholas J K Breitborde, Hermann Brenner, Zahid A Butt, Rosario Cárdenas, Lucero Cahuana-Hurtado, Ismael Ricardo Campos-Nonato, Josip Car, Juan Jesus Carrero, Daniel Casey, Valeria Caso, Carlos A Castañeda-Orjuela, Jacqueline Castillo Rivas, Ferrán Catalá-López, Pedro Cecilio, Kelly Cercy, Fiona J Charlson, Alan Z Chen, Adrienne Chew, Mirriam Chibalabala, Chioma Ezinne Chibueze, Vesper Hichilombwe Chisumpa, Abdulaal A Chitheer, Rajiv Chowdhury, Hanne Christensen, Devasahayam Jesudas Christopher, Liliana G Ciobanu, Massimo Cirillo, Megan S Coggeshall, Leslie Trumbull Cooper, Monica Cortinovis, John A Crump, Koustuv Dalal, Hadi Danawi, Lalit Dandona, Rakhi Dandona, Paul I Dargan, Jose das Neves, Gail Davey, Dragos V Davitoui, Kairat Davletov, Diego De Leo, Liana C Del Gobbo, Borja del Pozo-Cruz, Robert P Dellavalle, Kebede Deribe, Amare Deribew, Don C Des Jarlais, Subhojit Dey, Samath D Dharmaratne, Daniel Dicker, Eric L Ding, Klara Dokova, E Ray Dorsey, Kerrie E Doyle, Manisha Dubey, Rebecca Ehrenkranz, Christian Lycke Ellingsen, Iqbal Elyazar, Ahmadali Enayati, Sergey Petrovich Ermakov, Babak Eshzari, Alireza Esteghamati, Kara Estep, Thomas Fürst, Imad D A Faghmous, Fanuel Belayneh Bekele Fanuel, Emerito Jose Aquino Faraon, Talha A Farid, Carla Sofia e Sa Farinha, Andre Faro, Maryam S Farvid, Farshad Farzadfar, Valery L Feigin, Andrea B Feigl, Seyed-Mohammad Fereshtehnejad, Jefferson G Fernandes, João C Fernandes, Tesfaye Regassa Feyissa, Florian Fischer, Christina Fitzmaurice, Thomas D Fleming, Nataliya Foigt, Kyle J Foreman, Mohammad H Forouzanfar, Richard C Franklin, Joseph Frostad, Tsegaye Tewelde G/hivot, Emmanuela Gakidou, Ketevan Gambashidze, Amiran Gamkrelidze, Wayne Gao, Alberto L Garcia-Basteiro, Teshome Gebre, Amanuel Tesfay Gebremedhin, Mengistu Welday Gebremichael, Alemseged Aregay Gebru, Amha Admasie Gelaye, Johanna M Geleijnse, Ricard Genova-Maleras, Katherine B Gibney, Ababi Zergaw Giref, Melkamu Dedefo Gishu, Giorgia Giussani, William W Godwin, Audra Gold, Ellen M Goldberg, Philimon N Gona, Amador Goodridge, Sameer Vali Gopalani, Atsushi Goto, Nicholas Graetz, Felix Greaves, Max Griswold, Peter Imre Guban, Harish Chander Gugrani, Prakash C Gupta, Rahul Gupta, Rajeev Gupta, Tanush Gupta, Vipin Gupta, Tesfa Dejenie Habtewold, Nima Hafezi-Nejad, Demewoz Haile, Alemayehu Desalegne Hailu, Gessesew Bugssa Hailu, Alex Hakuzimana, Randah Ribhi Hamadeh, Mitiku Teshome Hambisa, Samer Hamidi, Mouhanad Hammami, Graeme J Hankey, Yuantao Hao, Hilda L Harb, Habtamu Abera Hareri, Josep Maria Haro, Mohammad Sadegh Hassanvand, Rasmus Havmoeller, Roderick J Hay, Simon I Hay, Delia Hendrie, Ileana Beatriz Heredia-Pi, Hans W Hoek, Masako Horino, Nobuyuki Horita, H Dean Hosgood, Aung Soe Htet, Guoqing Hu, Hsiang Huang, John J Huang, Bethany M Huntley, Chantal Huynh, Kim Moesgaard Iburg, Bogdan Vasile Ileanu, Kaire Innos, Asnake Ararsa Irenso, Nader Jahanmeh, Mihajlo B Jakovljevic, Peter James, Spencer Lewis James, Mehdi Javanbakht, Sudha P Jayaraman, Achala Upendra Jayatilleke, Panniyammakal Jeemon, Vivekanand Jha, Denny John, Catherine Johnson, Sarah C Johnson, Jost B Jonas, Knud Juel, Zubair Kabir, Yogeshwar Kalkonde, Ritul Kamal, Haidong Kan, Andre Karch, Corine Kakizi Karema, Seyed M Karimi, Amir Kasaecian, Nicholas J Kassebaum, Anshul Kastor, Srinivasa Vittal Katikireddi, Konstantin Kazanjan, Peter Njenga Keiyoro, Laura Kemmer, Andrew Haddon Kemp, Andre Pascal Kengne, Amene Abebe Kerbo, Maia Kereselidze, Chandrasekharan Nair Kesavachandran, Yousef Saleh Khader, Ibrahim Khalil, Abdur Rahman Khan, Ejaz Ahmad Khan, Gulfaraz Khan, Young-Ho Khang, Abdullah Tawfiq Abdullah Khoda, Irma Khonelidze, Jagdish Khubchandani, Getiye Dejen Kibret, Daniel Kim, Pauline Kim, Yun Jin Kim, Ruth W Kimokoti, Yohannes Kinfu, Niranjana Kissoon, Miia Kivipelto, Yoshihiro Kokubo, Anneli Kolk, Dhaval Kolte, Jacek A Kopec, Soewarta Kosen, Parvaiz A Koul, Ai Koyanagi, Michael Kravchenko, Sanjay Krishnaswami, Kristopher J Krohn, Barthelmy Kuate Defo, Burcu Kucuk Bicer, Ernst J Kuipers, Veena S Kulkarni, G Anil Kumar, Fekede Asefa Kumsa, Michael Kutz, Hmwe H Kyu, Anton Carl Jonas Lager, Aparna Lal, Dharmesh Kumar Lal, Ratilal Laloo, Tea Lallukka, Qing Lan, Sinead M Langan, Van C Lansingh, Heidi J Larson, Anders Larsson, Dennis Odai Laryea, Asma Abdul Latif, Alicia Elena Beatriz Lawryniewicz, Janet L Leasher, James Leigh, Mall Leinsalu, Cheru Tesema Leshargie, Janni Leung, Ricky Leung, Miriam Levi, Xiaofeng Liang, Stephen S Lim, Margaret Lind, Shai Linn, Steven E Lipshultz, Patrick Liu, Yang Liu, Loon-Tzian Lo, Giancarlo Logroscino, Alan D Lopez, Scott A Lorch, Paulo A Lotufo, Rafael Lozano, Raimundas Lunevicius, Roman A Lyons, Erlyn Rachele King Macarayan, Mark T Mackay, Hassan Magdy Abd El Razek, Mohammed Magdy Abd El Razek, Mahdi Mahdavi, Azeem Majeed, Reza Malekzadeh, Deborah Carvalho Malta, Lorenzo G Mantovani, Tsegahun Manyazewal, Chabila C Mapoma, Wagner Marcenés, Guy B Marks, Neal Marquez, Jose Martinez-Raga, Melvin Barrientos Marzan, João Massano, Manu Raj Mathur, Pallab K Maulik, Mohsen Mazidi, Colm McAlinden, John J McGrath, Claire McNellan, Peter A Meaney, Alem Mehari, Man Mohan Mehndiratta, Toni Meier, Alemayehu B Mekonnen, Kidanu Gebremariam Meles, Ziad A Memish, Melkamu Merid Mengesha, Desalegn Tadesse Mengiste, Mubarek Abera Mengistie, Bereket Gebremichael Menota, George A Mensah, Seid Tiku Mereta, Atte Meretoja, Tuomo J Meretoja, Haftay Berhane Mezgebe, Renata Micha, Anoushka Millar, Edward J Mills, Shawn Minnig, Mojde Mirarefin, Erkin M Mirrakhimov, Charles N Mock, Karzan Abdulmuhsin Mohammad, Shafiu Mohammed, Sanjay K Mohanty, Ali H Mokdad, Glen Liddell D Mola, Mariam Molokhia, Lorenzo Monasta, Marcella Montico, Maziar Moradi-Lakeh, Paula Moraga, Lidia Morawska, Rintaro Mori, Mark Moses, Ulrich O Mueller, Srinivas Murthy, Kamarul Imran Musa, Jean B Nachega, Chie Nagata, Gabriele Nagel, Mohsen Naghavi, Aliya Naheed, Luigi Naldi, Vinay Nangia, Bruno Ramos Nascimento, Ionut Nego, Sudan Prasad Neupane, Charles R Newton, Marie Ng, Frida Namnyak Ngalesoni, Josephine Wanjiku Ngunjiri, Grant Nguyen, Dina Nur Anggraini Ningrum, Sandra Nolte, Marika Nomura, Ole F Norheim, Bo Norrving, Jean Jacques N Noubiap, Carla Makhlof Obermeyer, Felix Akpojene Ogbo, In-Hwan Oh, Anselm Okoro, Olanrewaju Oladimeji, Andrew Toyin Olagunju, Pedro R Olivares, Helen E Olsen, Bolajoko Olubukunola Olusanya, Jacob Olusegun Olusanya, John Nelson Opio, Eyal Oren, Alberto Ortiz, Richard H Osborne, Majdi Osman, Mayowa O Owolabi, Mahesh PA, Amanda W Pain, Smita Pakhale, Elizabeth Palomares Castillo, Adrian Pana, Christina Papachristou, Mahboubeh Parsaeian, Tejas Patel, George C Patton, Deepak Paudel, Vinod K Paul, Neil Pearce, David M Pereira, Rogelio Perez-Padilla, Fernando Perez-Ruiz, Norberto Perico, Konrad Pesudovs, Max Petzold, Michael Robert Phillips, David M Pigott, Julian David Pillay, Christine Pinho, Suzanne Polinder, Constance D Pond, V Prakash, Manorama Purwar, Mostafa Qorbani, D Alex Quistberg, Amir Radfar, Anwar Rafay, Kazem Rahimi, Vafa Rahimi-Movaghar, Mahfuzar Rahman, Mohammad Hifz Ur Rahman, Rajesh Kumar Rai, Usha Ram, Saleem M Rana, Zane Rankin, Paturi Vishnupriya Rao, Puja C Rao, Salman Rawaf, Maria Albertina Santiago Rego, Marissa Reitsma, Giuseppe Remuzzi, Andre M N N Renzaho, Serge Resnikoff, Satar Rezaei, Mohammad Sadegh Rezaei, Antonio L Ribeiro, Hirbo Shore Roba, Mohammad Bagher Rokni, Luca Ronfani, Gholamreza Roshandel, Gregory A Roth, Dietrich Rothenbacher, Nawal K Roy, Perminder S Sachdev, Ben Benasco Sackey, Mohammad Yahya Saeedi, Saeid Safiri, Rajesh Sagar, Mohammad Ali Sahraian, Muhammad Muhammad Saleh, Joshua A Salomon, Abdallah M Samy, Juan Ramon Sanabria, Maria Dolores Sanchez-Niño, Logan Sandar, Itamar S Santos, João Vasco Santos, Milena M Santric Milicevic, Rodrigo Sarmiento-Suarez, Benn Sartorius, Maheswar Satpathy, Miloje Savic, Monika Sawhney, Mete I Saylan, Ben Schöttker, Aletta E Schutte, David C Schwebel, Soraya Seedat, Abdulbasit Musa Seid, Cnaan Negash Seifu, Sadaf G Sepanlou, Berrin Serdar, Edson E Servan-Mori, Tesfaye Setegn, Katya Anne Shackelford, Amira Shaheen, Saeid Shahraz, Masood Ali Shaikh, Marina Shakh-Nazarova, Mansour Shamsipour, Sheikh Mohammed Shariful Islam, Jayendra Sharma, Rajesh Sharma, Jun She, Sara Sheikhbaheai, Jiabin Shen, Peilin Shi, Mika Shigematsu,

Min-Jeong Shin, Rahman Shiri, Haitham Shoman, Mark G Shrim, Ephrem Lejore Sibamo Sibamo, Inga Dora Sigfusdottir, Diego Augusto Santos Silva, Dayane Gabriele Alves Silveira, Shireen Sindi, Abhishek Singh, Jasvinder A Singh, Om Prakash Singh, Prashant Kumar Singh, Virendra Singh, Abiy Hiruye Sinke, Akilil Endalamaw Sinshaw, Vegard Skirbekk, Karen Sliwa, Alison Smith, Eugene Sobngwi, Samir Soneji, Joan B Soriano, Tatiane Cristina Moraes Sousa, Luciano A Sposato, Chandrashekar T Sreeramareddy, Vasiliki Stathopoulou, Nicholas Steel, Caitlyn Steiner, Sabine Steinke, Mark Andrew Stokes, Saverio Stranges, Mark Strong, Konstantinos Stroumpoulis, Lela Sturua, Muawiyah Babale Sufiyan, Rizwan Abdulkader Suliankatchi, Jiandong Sun, Patrick Sur, Soumya Swaminathan, Bryan L Sykes, Rafael Tabarés-Seisdedos, Karen M Tabb, Getachew Redae Taffere, Roberto Tchio Talongwa, Musharaf Tarajia, Mohammad Tavakkoli, Nuno Taveira, Stephanie Teeple, Teketo Kassaw Tegegne, Arash Tehrani-Banihashemi, Tesfalidet Tekelab, Dejen Yemane Tekle, Girma Temam Shifa, Abdullah Sulieman Terkawi, Azeb Gebresilassie Tesema, JS Thakur, Alan J Thomson, Taavi Tillmann, Tenaw Yimer Tiruye, Ruoyan Tobe-Gai, Marcello Tonelli, Roman Topor-Madry, Miguel Tortajada, Christopher Troeger, Thomas Truelsen, Abera Kenay Tura, Uche S Uchendu, Kingsley N Ukwaia, Eduardo A Undurraga, Chigozie Jesse Uneke, Olalekan A Uthman, Job F M van Boven, Rita Van Dingenen, Santosh Varughese, Tommi Vasankari, Narayanaswamy Venketasubramanian, Francesco S Violante, Sergey K Vladimirov, Vasilij Victorovich Vlassov, Stein Emil Vollset, Theo Vos, Joseph A Wagner, Tolassa Wakayo, Stephen G Waller, Judd L Walson, Haidong Wang, Yuan-Pang Wang, David A Watkins, Elisabete Weiderpass, Robert G Weintraub, Chi-Pang Wen, Andrea Werdecker, Joshua Wesana, Ronny Westerman, Harvey A Whiteford, James D Wilkinson, Charles Shey Wiysonge, Belete Getahun Woldeyes, Charles D A Wolfe, Sungho Won, Abdulhalik Workicho, Shimelash Bitew Workie, Mamo Wubshet, Denis Xavier, Gelin Xu, Ajit Kumar Yadav, Mohsen Yaghoubi, Bereket Yakob, Lijing L Yan, Yuichiro Yano, Mehdi Yaseri, Hassen Hamid Yimam, Paul Yip, Naohiro Yonemoto, Seok-Jun Yoon, Mustafa Z Younis, Chuanhua Yu, Zoubida Zaidi, Maysaa El Sayed Zaki, Carlos Zambrana-Torrel, Tomas Zapata, Zerihun Menlkalew Zenebe, Sanjay Zodpey, Leo Zoeckler, Liesl Joanna Zuhlke, Christopher J L Murray.

Affiliations

Institute for Health Metrics and Evaluation (R M Barber BS, N Fullman MPH, R J D Sorensen MPH, A Afshin MD, L Alexander BA, C Allen BA, S Biryukov BS, Prof M Brauer ScD, D Casey BA, K Cercy BS, F J Charlson PhD, A Z Chen BS, A Chew ND, M S Coggeshall BA, Prof L Dandona MD, R Dandona PhD, D Dicker BS, R Ehrenkranz MPH, K Estep MPA, C Fitzmaurice MD, T D Fleming BS, K J Foreman PhD, J Frostad MPH, Prof E Gakidou PhD, W W Godwin BS, A Gold MSc, E M Goldberg BS, N Graetz MPH, M Griswold MS, Prof S I Hay DSc, B M Huntley BA, C Huynh BA, C Johnson PhD, S C Johnson MSc, N J Kassebaum MD, L Kemmer PhD, I Khalil MD, P Kim BA, K J Krohn BA, M Kutz BS, H H Kyu PhD, H J Larson PhD, Prof S Lim PhD, M Lind MPH, P Liu BA, N Marquez BA, C McNellan BA, A Millea BA, S Minnig MSc, M Mirarefin MPH, Prof A H Mokdad PhD, M Moradi-Lakeh MD, M Moses MHS, Prof M Naghavi PhD, M Ng PhD, G Nguyen MPH, H E Olsen MA, A W Pain MPH, D M Pigott DPhil, C Pinho BA, Z Rankin BS, P C Rao MPH, M Reitsma BS, G A Roth MD, L Sandar BS, K A Shackelford BA, A Smith BA, C Steiner MPH, P Sur BA, S Teeple BA, C Troeger MPH, Prof S E Vollset DrPH, Prof T Vos PhD, J A Wagner BS, H Wang PhD, Prof H A Whiteford PhD, L Zoeckler BA, Prof C J L Murray DPhil, Division of Hematology, Department of Medicine (C Fitzmaurice MD), Harborview Injury Prevention and Research Center (C N Mock PhD, D A Quistberg PhD), Department of Anesthesiology & Pain Medicine, (D A Quistberg PhD), University of Washington, Seattle, WA, USA (Prof B O Anderson MD, J Leung PhD, J L Walson MD, D A Watkins MD); Council on Foreign Relations, Washington DC, Washington DC, USA (T Bollyky JD); European Observatory on Health Systems and Policies (E Nolte PhD), Department of Infectious Disease Epidemiology

(H J Larson PhD), London School of Hygiene & Tropical Medicine, London, UK (Prof M McKee DSc, I M O Adetifa PhD, I D A Faghmous MPH, S M Langan PhD, Prof N Pearce PhD); School of Public Health (A A Abajobir MPH, F J Charlson PhD, J Leung PhD, Prof H A Whiteford PhD), School of Dentistry (Prof R Lalloo PhD), University of Queensland, Brisbane, QLD, Australia (Prof J J McGrath MD); College of Health Sciences, Department of Epidemiology, ICT and e-Learning Coordinator (M B Ahmed MPH), Jimma University, Jimma, Ethiopia (K H Abate MS, T T Ghiwot MPH, A T Gebremedhin MPH, M A Mengistie MS, S T Mereta PhD, T Wakayo MS, A Workicho MPH); La Sapienza, University of Rome, Rome, Italy (C Abbafati PhD); Virginia Tech, Blacksburg, VA, USA (Prof K M Abbas PhD); Department of Neurology, Cairo University, Cairo, Egypt (Prof F Abd-Allah MD); New York University Abu Dhabi, Abu Dhabi, United Arab Emirates (A M Abdulle PhD); Uro-oncology Research Center (E Amini MD), Endocrinology and Metabolism Population Sciences Institute Research Institute (E Amini MD, Prof A Esteghamati MD, S Sheikhbahaie MD, N Hafezi-Nejad MD, A Kasaieian PhD), Non-Communicable Diseases Research Center (F Farzadfar MD, M Parsaieian PhD), Department of Epidemiology and Biostatistics, School of Public Health (M Parsaieian PhD), Center for Air Pollution Research (M S Hassanvand PhD), Institute for Environmental Research (M Shamsipour PhD), Hematology-Oncology and Stem Cell Transplantation Research Center (A Kasaieian PhD), Digestive Diseases Research Institute (Prof R Malekzadeh MD, G Roshandel PhD, S G Sepanlou PhD), Sina Trauma and Surgery Research Center (Prof V Rahimi-Movaghar MD), MS Research Center, Neuroscience Institute (M A Sahraian MD), Tehran University of Medical Sciences, Tehran, Iran (A A Abdurahaman PhD, Prof M B Rokni PhD); School of Public Health (S F Abera MSc, G F Abreha MPH, K G Meles MPH, G R Taffere PhD), College of Health Sciences (D T Mengiste MS), Department of Medical Microbiology and Immunology (K Adane MS), Mekelle University, Mekelle, Ethiopia (T M Atey MS, M W Gebremichael MS, A A Gebbru MPH, G B Hailu MSc, H B Mezgebe MS, D Y Tekle MS, A G Tesema MPH, Z M Zenebe MS); Food Security and Institute for Biological Chemistry and Nutrition, University of Hohenheim, Stuttgart, Germany (S F Abera MSc); NMSM Government College Kalpetta, Kerala, India (Prof B Abraham MPhil); Public Health Promotion Alliance, Osogbo, Nigeria (A L Adekan MPH); University of Ibadan, Ibadan, Nigeria (A L Adekan MPH, R O Akinyemi PhD); KEMRI-Wellcome Trust Research Programme, Kilifi, Kenya (I M O Adetifa PhD, A Deribew PhD); Dalla Lana School of Public Health (N Akseer MSc), Department of Nutritional Sciences, Faculty of Medicine (A Badawi PhD), University of Toronto, Toronto, ON, Canada (A Agarwal BHSc); McMaster University, Hamilton, ON, Canada (A Agarwal BHSc); All India Institute of Medical Sciences, New Delhi, India (Prof S K Agarwal, V K Paul MD, R Sagar MD, M Satpathy PhD); National Institute of Occupational Health (ICMR), Ahmedabad, India (S Agarwal PhD); CSIR - Institute of Genomics and Integrative Biology, Delhi, India (A Agrawal PhD); Department of Internal Medicine, Baylor College of Medicine, Houston, TX, USA (A Agrawal PhD); Department of Clinical Sciences Lund, Orthopedics, Clinical Epidemiology Unit (A Ahmad Kiadaliri PhD), Skane University Hospital, Department of Clinical Sciences Lund, Neurology, Lund University, Lund, Sweden (Prof B Norrving PhD); School of Public Health (S Rezaei PhD), Kermanshah University of Medical Sciences, Kermanshah, Iran (A Ahmadi PhD); Debre Markos University, Debre Markos, Ethiopia (K Y Ahmed MPH, Z A Alemu MPH, G D Kibret MPH, C T Leshargie MPH, T K Tegegne MPH, T Y Tiruye MPH); Newcastle University, Newcastle upon Tyne, UK (R O Akinyemi PhD); Department of Epidemiology (T F Akinyemiju PhD), University of Alabama at Birmingham, Birmingham, AL, USA (D C Schwebel PhD); Centre for Global Child Health, The Hospital for Sick Children, Toronto, ON, Canada (N Akseer, Z A Bhutta PhD); Washington University in Saint Louis, St. Louis, MO, USA (Z Al-Aly MD); Murdoch Childrens Research Institute (K Alam PhD), University of Melbourne, Melbourne, VIC, Australia (K Alam PhD); The University of Sydney, Sydney, NSW, Australia (K Alam PhD); Department of Health, Queensland, Brisbane, QLD, Australia (N Alam MAppEpid); International Centre for Diarrhoeal Disease Research (ICDDR), Bangladesh, Dhaka, Bangladesh (S S Alam MSc, A Naheed PhD, S M Shariful Islam PhD); Department

of Epidemiology and Biostatistics, Institute of Public Health (K A Alene MPH), University of Gondar, Gondar, Ethiopia (A B Mekonnen MS); Nuffield Department of Medicine (D Bisanzio PhD, A Deribew PhD), Oxford Big Data Institute, Li Ka Shing Centre for Health Information and Discovery (Prof S I Hay DSc), University of Oxford, Oxford, UK (R Ali FRCP, D A Bennett PhD, Prof V Jha DM, K Rahimi DM); University of London, London, UK (S D Ali BA); SIR management consultants, Oxford, UK (S D Ali BA); Institute and Faculty of Actuaries, Oxford, UK (S D Ali BA); Gastrointestinal Cancer Research Center (R Alizadeh-Navaei PhD), Mazandaran University of Medical Sciences, Sari, Iran (M S Rezai MD); Luxembourg Institute of Health (LIH), Strassen, Luxembourg (A Alkerwi PhD, S Stranges PhD); School of Public Health, University of Lorraine, Nancy, France (Prof F Alla PhD); Department of Public Health Sciences (P Allebeck PhD), Division of Family Medicine and Primary Care, Department of Neurobiology, Care Science and Society (Prof J Ärnlöv PhD), Department of Clinical Science, Intervention and Technology (Prof J J Carrero PhD), Department of Neurobiology, Care Sciences and Society (NVS) (S Fereshtehnejad PhD), Aging Research Center (Prof M Kivipelto PhD), Department of Medical Epidemiology and Biostatistics (E Weiderpass PhD), Karolinska Institutet, Stockholm, Sweden (R Havmoeller PhD, S Sindi PhD); Ministry of Health, Jeddah, Saudi Arabia (R Al-Raddadi PhD); Department of Psychosomatic Medicine, Center for Internal Medicine and Dermatology (S Nolte PhD), Charité University Medicine Berlin, Berlin, Germany (U Alsharif MPH, C Papachristou PhD); King Saud University, Riyadh, Saudi Arabia (K A Altirkawi MD); Spanish Observatory on Drugs, Government Delegation for the National Plan on Drugs, Ministry of Health, Social Policy and Equality, Madrid, Spain (E Alvarez Martin PhD); Universidad de Cartagena, Cartagena de Indias, Colombia (Prof N Alvis-Guzman PhD); School of Medicine (A T Amare MPH, Prof B T Baune PhD), University of Adelaide, Adelaide, SA, Australia (A T Olagunju MS, L G Ciobanu MS); College of Medicine and Health Sciences (A T Amare MPH), Bahir Dar University, Bahir Dar, Ethiopia (T Setegn MPH); Ministry of Public Health, Beirut, Lebanon (W Ammar PhD, H L Harb MPH); African Population and Health Research Center, Nairobi, Kenya (J Amo-Adjei PhD); University of Cape Coast, Cape Coast, Ghana (J Amo-Adjei PhD); Department of Medicine (Y A Amoako FWACP), Komfo Anokye Teaching Hospital, Kumasi, Ghana (D O Laryea MD); University of Thessaly, Larissa, Greece (Prof S Androudi MD); Health Promotion Research Center, Department of Epidemiology and Biostatistics, Zahedan University of Medical Sciences, Zahedan, Iran (H Ansari PhD); West Hararghe Zonal Health Department, Chiro, Ethiopia (M G Ansha MPH); Department of Health Policy and Administration, College of Public Health (C A T Antonio MD), College of Public Health (E J A Faraon MD), University of the Philippines Manila, Manila, Philippines; School of Health and Social Studies, Dalarna University, Falun, Sweden (Prof J Ärnlöv PhD); University of Manitoba, Winnipeg, MB, Canada (A Artaman PhD); Department of Medical Emergency, School of Paramedic, Qom University of Medical Sciences, Qom, Iran (H Asayesh PhD); Mashhad University of Medical Sciences, Mashhad, Iran (R Assadi PhD); Hawassa University, Hawassa, Ethiopia (A Astatkie PhD, F B B Fanuel MPH); Graduate Institute of Biomedical Informatics (S Atique MS), College of Medical Science and Technology, Taipei Medical University, Taipei, Taiwan (D N A Ningrum MPH); Mizan Tepi University, Mizan Teferi, Ethiopia (N T Atnafu MS, H H Yimam MPH); PMA 2020, Mizan Teferi, Ethiopia (N T Atnafu MS); Clinical Trials Unit, BJ Medical College - Johns Hopkins University, Pune, India (S R Atre PhD); National Institute of Public Health, Cuernavaca, Mexico (L Avila-Burgos PhD); Institut de Recherche Clinique du Bénin (IRCB), Cotonou, Benin (E F G A Avokpaho MPH); Laboratoire d'Etudes et de Recherche-Action en Santé (LERAS Afrique), Parakou, Benin (E F G A Avokpaho MPH); The Judith Lumley Centre for Mother, Infant and Family Health Research, La Trobe University, Melbourne, VIC, Australia (B P Ayala Quintanilla PhD); Peruvian National Institute of Health, Lima, Peru (B P Ayala Quintanilla PhD); Sanjay Gandhi Postgraduate Institute of Medical Sciences, Lucknow, India (A Awasthi PhD); Ministry of Health, Addis Ababa, Ethiopia (N N Ayele MPH); Department of Paediatrics (P Azzopardi MEpi), Murdoch Childrens Research Institute (K Alam PhD, P Azzopardi MEpi, R G Weintraub MBBS, Prof G C Patton MD), Department of Paediatrics (P Azzopardi MEpi), Melbourne School of Population and Global Health (Prof A D Lopez PhD), Department of Medicine (A Meretoja PhD), University of Melbourne, Melbourne, VIC, Australia (K Alam PhD); Wardlapingga Aboriginal Research Unit, South Australian Health and Medical Research Institute, Adelaide, SA, Australia (P Azzopardi MEpi); Centre for International Health, Burnet Institute, Melbourne, VIC, Australia (P Azzopardi MEpi); Faculty of Medicine and Health Sciences, Aden University, Aden, Yemen (Prof H O Ba Saleem PhD); Department of Global Health and Population (Prof T Bärnighausen MD, A B Feigl ScD, J A Salomon PhD), Department of Epidemiology (P James ScD), Department of Nutrition (M S Farvid PhD), Harvard T.H. Chan School of Public Health, (I R Campos-Nonato PhD, E L Ding ScD), Harvard Medical School, Harvard University, Boston, MA, USA (M Osman MD, M G Shrimme MD); Africa Health Research Institute, Mtubatuba, South Africa (Prof T Bärnighausen MD); Institute of Public Health, Heidelberg University, Heidelberg, Germany (Prof T Bärnighausen MD, S Mohammed PhD); School of Health Sciences, University of Management and Technology, Lahore, Pakistan (U Bacha PhD); Public Health Agency of Canada, Toronto, ON, Canada (A Badawi PhD); Farr Institute of Health Informatics Research (A Banerjee DPhil), Institute of Epidemiology & Health (T Tillmann MSc), University College London, London, UK (C Birungi MS); Faculty of Medicine (A Barac PhD), Institute of Social Medicine (M M Santric Milicevic PhD), Centre School of Public Health and Health Management, Faculty of Medicine (M M Santric Milicevic PhD), University of Belgrade, Belgrade, Serbia; Hospital Dr. Rafael A. Calderón Guardia, CCSS, San Jose, Costa Rica (M A Barboza MD); Universidad de Costa Rica, San Pedro, Costa Rica (M A Barboza MD); School of Psychology (S L Barker-Collo PhD), University of Auckland, Auckland, New Zealand (B del Pozo-Cruz PhD); Department of Industrial Engineering, School of Engineering, Pontificia Universidad Javeriana, Bogota, Colombia (L H Barrero ScD); Stanford University, Stanford, CA, USA (S Basu PhD, L C Del Gobbo PhD); School of Public Health (K Deribe MPH, A D Hailu MPH), Addis Ababa University, Addis Ababa, Ethiopia (K Baye PhD, T J Beyene MS, A Z Giref PhD, D Haile MPH, H A Hareri MS, B G Menota MS, G Temam Shifa MPH, B G Woldeyes MPH); Jhpiego-Ethiopia, Addis Ababa, Ethiopia (Y T Bayou PhD); College of Medicine, Charles R. Drew University of Medicine and Science, Los Angeles, CA, USA (Prof S Bazargan-Hejazi PhD); David Geffen School of Medicine, University of California at Los Angeles, Los Angeles, CA, USA (Prof S Bazargan-Hejazi PhD); College of Public Health and Tropical Medicine, Jazan, Saudi Arabia (N Bedi MD); IRCCS - Istituto di Ricerche Farmacologiche Mario Negri, Milan, Italy (E Beghi MD, G Giussani BiolD); University Hospital and Medical School of Dijon, University of Burgundy, Dijon, France (Prof Y Béjot PhD); University of Alberta, Edmonton, AB, Canada (A K Bello PhD); Internal Medicine Department (Prof I S Santos PhD), University of Sao Paulo, Sao Paulo, Brazil (I M Bensenor PhD, Prof P A Lotufo DrPH); College of Health Sciences (A Berhane PhD), Debre Berhan University, Debre Berhan, Ethiopia (T D Habtewold MS); Division of Health and Social Care Research (Prof C D Wolfe MD), King's College London, London, UK (E Bernabé PhD, Prof R J Hay DM, M Molokhia PhD); University Andes, Bogota, Colombia (O A Bernal PhD); College of Health and Medical Sciences (A S Beyene MPH, M T Hambisa MPH, M M Mengesha MPH, H S Roba MPH, A M Seid MS), Haramaya University, Dire Dawa, Ethiopia (M D Gishu MS, A A Irenso MPH, F A Kumsa MPH, A K Tura MPH); Division of Human Nutrition (J M Geleijnse PhD), Wageningen University, Wageningen, Netherlands (T J Beyene MS); Centre of Excellence in Women and Child Health, Aga Khan University, Karachi, Pakistan (Z A Bhutta PhD); Independent Public Health Consultants, Addis Ababa, Ethiopia (S Biadgilign MPH); IRCCS - Istituto di Ricerche Farmacologiche Mario Negri, Bergamo, Italy (B Bikbov MD, M Cortinovis Biotech D, Prof G Remuzzi MD); GBS-CIDP International Foundation, Menemen, Turkey (S M Birlik BS); Debre Markos University, Debre Markos town, Ethiopia (H M Bizuayehu MPH); World Bank, Washington DC, DC, USA (D Bose PhD); Danube-University Krems, Krems, Austria (Prof M Brainin PhD); University of British Columbia, Vancouver, BC, Canada (Prof M Brauer ScD, Prof N Kissoon MD, J A Kopec PhD,

- S Murthy MD); Faculty of Health Sciences and Social Work, Department of Public Health, Trnava University, Trnava, Slovakia (A Brazinova PhD); International Neurotrauma Research Organization, Vienna, Austria (A Brazinova PhD); College of Medicine (J Shen PhD), Ohio State University, Columbus, OH, USA (Prof N J K Breitborde PhD); Division of Clinical Epidemiology and Ageing Research (B Schöttker MPH), German Cancer Research Center, Heidelberg, Germany (Prof H Brenner MD); Al Shifa Trust Eye Hospital, Rawalpindi, Pakistan (Z A Butt PhD); Metropolitan Autonomous University, Mexico City, Mexico (R Cárdenas ScD); National Institute of Public Health, Cuernavaca, Mexico (L Cahuana-Hurtado PhD, I R Campos-Nonato PhD, I B Heredia-Pi PhD, R Lozano MD, Prof E E Servan-Mori MSc); Nanyang Technological University, Singapore, Singapore (J Car PhD); Stroke Unit, University of Perugia, Perugia, Italy (V Caso MD); Colombian National Health Observatory, Instituto Nacional de Salud, Bogota, Colombia (C A Castañeda-Orjuela MSc); Epidemiology and Public Health Evaluation Group, Public Health Department, Universidad Nacional de Colombia, Bogota, Colombia (C A Castañeda-Orjuela MSc); Caja Costarricense de Seguro Social, San Jose, Costa Rica (Prof J Castillo Rivas MPH); Universidad de Costa Rica, San Pedro, Montes de Oca, Costa Rica (Prof J Castillo Rivas MPH); Department of Medicine, University of Valencia/INCLIVA Health Research Institute and CIBERSAM, Valencia, Spain (F Catalá-López PhD); Clinical Epidemiology Program, Ottawa Hospital Research Institute, Ottawa, ON, Canada (F Catalá-López PhD); Independent Collaborator, Porto, Portugal (P Cecilio MS); Queensland Centre for Mental Health Research, Brisbane, QLD, Australia (F J Charlson PhD, Prof H A Whiteford PhD); Crowd Watch Africa, Lusaka, Zambia (M Chibabalaba BS); National Center for Child Health and Development, Setagaya ku, Japan (C E Chibueze PhD); University of Zambia, Lusaka, Zambia (V H Chisumpa MPhil, C C Mapoma PhD); University of Witwatersrand, Johannesburg, South Africa (V H Chisumpa MPhil); Ministry of Health, Baghdad, Iraq (A A Chitheer FETP); Department of Public Health and Primary Care, University of Cambridge, Cambridge, UK (R Chowdhury PhD); Bispebjerg University Hospital, Copenhagen, Denmark (Prof H Christensen DMSc); Christian Medical College, Vellore, India (Prof D J Christopher MD, Prof S Varughese DM); School of Medicine (A T Amare MPH, Prof B T Baune PhD); University of Salerno, Baronissi, Italy (Prof M Cirillo MD); Mayo Clinic, Jacksonville, FL, USA (L T Cooper MD); Centre for International Health, Dunedin School of Medicine, University of Otago, Dunedin, New Zealand (Prof J A Crump MD); Centre for Injury Prevention and Safety Promotion, School of Health and Medical Sciences, Örebro University, Örebro, Sweden (Prof K Dalal PhD); Walden University, Minneapolis, MN, USA (H Danawi PhD); Centre for Control of Chronic Conditions (P Jeemon PhD), Public Health Foundation of India, New Delhi, India (Prof L Dandona MD, R Dandona PhD); Guy's and St. Thomas' NHS Foundation Trust, London, UK (P I Dargan FRCP); i3S - Instituto de Investigação e Inovação em Saúde (J das Neves PhD), INEB - Instituto de Engenharia Biomédica (J das Neves PhD), Faculty of Medicine, University of Porto, Porto, Portugal (J Massano MD, J V Santos BHLthSc); Wellcome Trust Brighton & Sussex Centre for Global Health Research, Brighton, UK (Prof G Davey MD); University of Medicine and Pharmacy Bucharest, Bucharest, Romania (D V Davitciu PhD); Republican Institute of Cardiology and Internal Diseases, Almaty, Kazakhstan (K Davletov PhD); School of Public Health, Kazakh National Medical University, Almaty, Kazakhstan (K Davletov PhD); Griffith University, Brisbane, QLD, Australia (Prof D De Leo DSc); University of Colorado School of Medicine and the Colorado School of Public Health, Aurora, CO, USA (R P Dellavalle MD); Brighton and Sussex Medical School, Brighton, UK (K Deribe MPH); Mount Sinai Beth Israel, New York, NY, USA (Prof D C Des Jarlais PhD); Icahn School of Medicine at Mount Sinai, New York City, NY, USA (Prof D C Des Jarlais PhD); Indian Institute of Public Health-Delhi, Public Health Foundation of India, Gurgaon, India (S Dey PhD, Prof S Zodepy PhD); Department of Community Medicine, Faculty of Medicine, University of Peradeniya, Peradeniya, Sri Lanka (S D Dharmaratne MD); Department of Social Medicine, Faculty of Public Health, Medical University - Varna, Varna, Bulgaria (K Dokova PhD); University of Rochester Medical Center, Rochester, NY, USA (E R Dorsey MD); RMIT University, Bundoora, VIC, Australia (Prof K E Doyle PhD); Australian National University, Canberra, ACT, Australia (Prof K E Doyle PhD); International Institute for Population Sciences, Mumbai, India (M Dubey MPhil, A Kastor MPhil, S K Mohanty MD, M H U Rahman MPhil, Prof U Ram PhD, A Singh PhD, A K Yadav MPhil); Center for Disease Burden (Prof S E Vollset), Norwegian Institute of Public Health, Oslo, Norway (C L Ellingsen MD, M Savic PhD, Prof V Skirbekk PhD); Eijkman-Oxford Clinical Research Unit, Jakarta, Indonesia (I Elyazar PhD); School of Public Health and Health Sciences Research Center, Sari, Iran (Prof A Enayati PhD); The Institute of Social and Economic Studies of Population, Russian Academy of Sciences, Moscow, Russia (Prof S P Ermakov DSc); Federal Research Institute for Health Organization and Informatics, Ministry of Health of the Russian Federation, Moscow, Russia (Prof S P Ermakov DSc); Ministry of Health and Medical Education, Tehran, Iran (B Eshtrati PhD); Arak University of Medical Sciences, Arak, Iran (B Eshtrati PhD); Department of Infectious Disease Epidemiology (T Fürst PhD), Imperial College London, London, UK (K J Foreman PhD, F Greaves PhD, Prof A Majeed MD, Prof S Rawaf MD); Department of Epidemiology and Public Health (T Fürst PhD), Swiss Tropical and Public Health Institute, Basel, Switzerland (C K Karema MSc); University of Basel, Basel, Switzerland (T Fürst PhD); Wolaita Sodo University, Wolaita Sodo, Ethiopia (F B B Fanuel MPH, A A Kerbo MPH, C N Seifu MS, E L S Sibamo MPH); Department of Health, Manila, Philippines (E J A Faraon MD); University of Louisville, Louisville, KY, USA (T A Farid MD, A R Khan MD); DGS Directorate General of Health, Lisboa, Portugal (C S E S Farinha MSc); Universidade Aberta, Lisboa, Portugal (C S E S Farinha MSc); Federal University of Sergipe, Aracaju, Brazil (Prof A Faro PhD); Harvard/MGH Center on Genomics, Vulnerable Populations, and Health Disparities, Mongan Institute for Health Policy, Massachusetts General Hospital, Boston, MA, USA (M S Farvid PhD); National Institute for Stroke and Applied Neurosciences, Auckland University of Technology, Auckland, New Zealand (V L Feigin PhD); Institute of Education and Sciences, German Hospital Oswaldo Cruz, Sao Paulo, Brazil (Prof J G Fernandes PhD); CBQF - Center for Biotechnology and Fine Chemistry - Associate Laboratory, Faculty of Biotechnology, Catholic University of Portugal, Porto, Portugal (J C Fernandes PhD); Wollega University, Nekemte, Ethiopia (T R Feyissa MPH, T Tekelab MS); School of Public Health, Bielefeld University, Bielefeld, Germany (F Fischer PhD); Fred Hutchinson Cancer Research Center, Seattle, WA, USA (C Fitzmaurice MD); Institute of Gerontology, Academy of Medical Science, Kyiv, Ukraine (N Foigt PhD); Seattle Genetics, Seattle, WA, USA (M H Ferozanfar PhD); James Cook University, Townsville, QLD, Australia (R C Franklin PhD); National Center for Disease Control and Public Health, Tbilisi, Georgia (K Gambashidze MS, K Kazanjian MS, M Kereselidze PhD, I Khonelidze MPA, M Shakh-Nazarova MS, L Sturua PhD); National Center for Disease Control & Public Health, Tbilisi, Georgia (A Gamkrelidze PhD); Health Policy (Prof C Wen PhD), National Health Research Institute, Taipei, Taiwan (W Gao PhD); Manhica Health Research Center, Manhica, Mozambique (A L Garcia-Basteiro MSc); Barcelona Institute for Global Health, Barcelona, Spain (A L Garcia-Basteiro MSc); The Task Force for Global Health, Decatur, GA, USA (T Gebre PhD); Ludwig Maximilians University, Munich, Germany (A T Gebremedhin MPH); Kite Awlaelo Health and Demographic Surveillance System, Mekelle, Ethiopia (A A Gebru MPH, G B Hailu MSc); Wolaita Sodo University, Sodo, Ethiopia (A A Gelaye MPH); Directorate General for Public Health, Regional Health Council, Madrid, Spain (R Genova-Maleras MS); National School of Public Health, Madrid, Spain (R Genova-Maleras MS); The Peter Doherty Institute for Infection and Immunity, University of Melbourne & The Royal Melbourne Hospital, Melbourne, VIC, Australia (K B Gibney FRACP); Kersa Health and Demographic Surveillance System, Harar, Ethiopia (M D Gishu MS); University of Massachusetts Boston, Boston, MA, USA (Prof P N Gona PhD); Instituto de Investigaciones Científicas y Servicios de Alta Tecnología - INDICASAT-AIP, Ciudad del Saber, Panama (A Goodridge PhD); Department of Health and Social Affairs, Government of the Federated States of Micronesia, Palikir, Federated States of Micronesia (S V Gopalani MPH); Division of Epidemiology, Center for Public Health Sciences, National Cancer Center, Tokyo, Japan (A Goto PhD); Public Health England, London, UK (F Greaves PhD, Prof N Steel PhD); Stockholm County

Council Surveillance and Analysis Centre for Epidemiology and Community Medicine, Solna, Sweden (P I Guban MSc); Departments of Microbiology and Epidemiology & Biostatistics, Saint James School of Medicine, The Quarter, Anguilla (Prof H C Gugnani PhD); Healix - Sekhsaria Institute for Public Health, Navi Mumbai, India (P C Gupta DSc); West Virginia Bureau for Public Health, Charleston, WV, USA (R Gupta MD); Eternal Heart Care Centre and Research Institute, Jaipur, India (R Gupta PhD); Montefiore Medical Center, Bronx, NY, USA (T Gupta MD); Department of Anthropology, University of Delhi, Delhi, India (V Gupta PhD); Department of Psychiatry, University Medical Center Groningen (Prof H W Hoek MD), University of Groningen, Groningen, Netherlands (T D Habtewold MS, A K Tura MPH, J F M van Boven PhD); Department of Global Public Health and Primary Care (Prof S E Vollset), University of Bergen, Bergen, Norway (A D Hailu MPH, Prof O F Norheim PhD); Faculty of Health Sciences, Hatter Institute for Cardiovascular Research in Africa (Prof K Sliwa PhD), University of Cape Town, Cape Town, South Africa (A Hakuzimana MPH, A P Kengne PhD, J J N Noubiap MD, D A Watkins MD); Euclid University, Banjul, The Gambia (A Hakuzimana MPH); Arabian Gulf University, Manama, Bahrain (Prof R R Hamadeh DPhil); Hamdan Bin Mohammed Smart University, Dubai, United Arab Emirates (S Hamidi DrPH); Wayne County Department of Health and Human Services, Detroit, MI, USA (M Hammami MD); School of Medicine and Pharmacology, University of Western Australia, Perth, WA, Australia (Prof G J Hankey MD); Harry Perkins Institute of Medical Research, Nedlands, WA, Australia (Prof G J Hankey MD); Western Australian Neuroscience Research Institute, Nedlands, WA, Australia (Prof G J Hankey MD); School of Public Health, Sun Yat-sen University, Guangzhou, China (Prof Y Hao PhD); College of Health and Medical Science (A S Beyene MPH), Haramaya University, Harar, Ethiopia (T A Hassen MS, F A Kumsa MPH, A A Irenso MPH); International Foundation for Dermatology, London, UK (Prof R J Hay DM); Centre for Population Health Research, Curtin University, Bentley, WA, Australia (D Hendrie MA); Department of Epidemiology, Mailman School of Public Health (Prof H W Hoek MD), Columbia University, New York, NY, USA (Prof V Skirbekk PhD); Department of Health and Human Services, Nevada Division of Public and Behavioral Health, Carson City, NV, USA (M Horino MPH); Department of Pulmonology, Yokohama City University Graduate School of Medicine, Yokohama, Japan (N Horita MD); Albert Einstein College of Medicine, Bronx, NY, USA (Prof H D Hosgood PhD); International Relations Division, Ministry of Health, Nay Pyi Taw, Myanmar (A S Htet MPhil); University of Oslo, Oslo, Norway (A S Htet MPhil, S P Neupane PhD); Department of Epidemiology and Health Statistics, School of Public Health, Central South University, Changsha, China (G Hu PhD); Cambridge Health Alliance, Cambridge, MA, USA (H Huang MD); Yale University, New Haven, CT, USA (J J Huang MD, E R K Macarayan PhD); Aarhus University, Aarhus, Denmark (K M Iburg PhD); Bucharest University of Economic Studies, Bucharest, Romania (B V Ileanu PhD, A Pana MPH); National Institute for Health Development, Tallinn, Estonia (K Innos PhD, M Leinsalu PhD); School of Public Health (N Jahanmehr PhD), Ophthalmic Research Center (M Yaseri PhD), Shahid Beheshti University of Medical Sciences, Tehran, Iran; Faculty of Medical Sciences, University of Kragujevac, Kragujevac, Serbia (Prof M B Jakovljevic PhD); Denver Health/University of Colorado, Denver, CO, USA (S L James MD); University of Aberdeen, Aberdeen, UK (M Javanbakht PhD); Department of Surgery, Virginia Commonwealth University, Richmond, VA, USA (S P Jayaraman MD); Postgraduate Institute of Medicine, Colombo 07, Sri Lanka (A U Jayatilake PhD); Institute of Violence and Injury Prevention, Colombo 08, Sri Lanka (A U Jayatilake PhD); Centre for Chronic Disease Control, New Delhi, India (P Jeemon PhD); Centre for Control of Chronic Conditions (P Jeemon PhD), Public Health Foundation of India, Gurugram, India (G A Kumar PhD); George Institute for Global Health, New Delhi, India (Prof V Jha DM); International Center for Research on Women, New Delhi, India (D John MPH); Department of Ophthalmology, Medical Faculty Mannheim, Ruprecht-Karls-University Heidelberg, Mannheim, Germany (Prof J B Jonas MD); The National Institute of Public Health, Copenhagen, Denmark (Prof K Juel PhD); University College Cork, Cork, Ireland (Z Kabir PhD); Society for Education, Action and Research in Community Health, Gadchiroli, India

(Y Kalkonde MD); CSIR - Indian Institute of Toxicology Research, Lucknow, India (R Kamal MSc, C N Kesavachandran PhD); Department of Pulmonary Medicine, Zhongshan Hospital (J She MD), Fudan University, Shanghai, China (H Kan MD); Epidemiological and Statistical Methods Research Group, Helmholtz Centre for Infection Research, Braunschweig, Germany (A Karch MD); Hannover-Braunschweig Site, German Center for Infection Research, Braunschweig, Germany (A Karch MD); Quality and Equity Health Care, Kigali, Rwanda (C K Karema MSc); University of Washington Tacoma, Tacoma, WA, USA (S M Karimi PhD); Department of Anesthesiology & Pain Medicine, Seattle Children's Hospital, Seattle, WA, USA (N J Kassebaum MD); University of Glasgow, Glasgow, UK (S V Katikireddi PhD); Institute of Tropical and Infectious Diseases, Nairobi, Kenya (P N Keiyo PhD); School of Continuing and Distance Education, Nairobi, Kenya (P N Keiyo PhD); Farr Institute (Prof R A Lyons MD), Swansea University, Swansea, UK (Prof A H Kemp PhD); Woolcock Institute of Medical Research (G B Marks PhD), University of Sydney, Camperdown, NSW, Australia (Prof A H Kemp PhD); South African Medical Research Council, Cape Town, South Africa (A P Kengne PhD); Jordan University of Science and Technology, Irbid, Jordan (Prof Y S Khader ScD); Health Services Academy, Islamabad, Pakistan (E A Khan MD); Department of Microbiology and Immunology, College of Medicine & Health Sciences, United Arab Emirates University, Al Ain, United Arab Emirates (G Khan PhD); College of Medicine (Prof Y Khang MD), Graduate School of Public Health (Prof S Won PhD), Seoul National University, Seoul, South Korea; Mohammed Ibn Saudi University, Riyadh, Saudi Arabia (A T A Khoja MD); Ball State University, Muncie, IN, USA (J Khubchandani PhD); Department of Health Sciences, Northeastern University, Boston, MA, USA (Prof D Kim DrPH); Southern University College, Skudai, Malaysia (Y J Kim PhD); Simmons College, Boston, MA, USA (R W Kimokoti MD); Centre for Research & Action in Public Health, Faculty of Health, University of Canberra, Canberra, ACT, Australia (Y Kinfu PhD); Department of Preventive Cardiology, National Cerebral and Cardiovascular Center, Suita, Japan (Y Kokubo PhD); Department of Pediatrics, Faculty of Medicine, University of Tartu, Tartu, Estonia (A Kolk PhD); Division of Cardiology, Brown University, Providence, RI, USA (D Kolte MD); Center for Community Empowerment, Health Policy and Humanities, NIHRI, Jakarta, Indonesia (S Kosen MD); Sher-i-Kashmir Institute of Medical Sciences, Srinagar, India (Prof P A Koul MD); Research and Development Unit, Parc Sanitari Sant Joan de Deu (CIBERSAM), Barcelona, Spain (Prof J M Haro PhD, A Koyanagi MD); Research Center of Neurology, Moscow, Russia (M Kravchenko PhD); Oregon Health and Science University, Portland, OR, USA (S Krishnaswami MD); Department of Demography and Public Health Research Institute (Prof B Kuate Defo PhD), Department of Social and Preventive Medicine, School of Public Health (Prof B Kuate Defo PhD), University of Montreal, Montreal, QC, Canada; Institute of Public Health, Hacettepe University, Ankara, Turkey (B Kucuk Bicer PhD); Department of Public Health (S Polinder PhD), Erasmus MC, University Medical Center Rotterdam, Rotterdam, Netherlands (Prof E J Kuipers PhD); Arkansas State University, State University, AR, USA (V S Kulkarni PhD); Centre for Epidemiology and Community Medicine, Stockholm County Council, Solna, Sweden (A C J Lager PhD); National Centre for Epidemiology and Population Health, The Australian National University, Canberra, ACT, Australia (A Lal PhD); Centre for Control of Chronic Conditions (P Jeemon PhD), Public Health Foundation of India, Gurgaon, India (D K Lal MD, M R Mathur PhD); Finnish Institute of Occupational Health, Work Organizations, Work Disability Program, Department of Public Health, Faculty of Medicine (T Lallukka PhD, R Shiri PhD), University of Helsinki, Helsinki, Finland (T J Meretoja PhD); National Cancer Institute, Rockville, MD, USA (Q Lan PhD); Help Me See, Inc, New York, NY, USA (V C Lansingh PhD); Instituto Mexicano de Oftalmología, Queretaro, Mexico (V C Lansingh PhD); Department of Medical Sciences, Uppsala University, Uppsala, Sweden (Prof A Larsson PhD); Department of Zoology, Lahore College for Women University, Lahore, Pakistan (A A Latif PhD); Instituto Nacional de Epidemiología Dr. Juan H. Jara, Mar del Plata, Argentina (A E B Lawrynovicz MPH); College of Optometry, Nova Southeastern University, Fort Lauderdale, FL, USA (J L Leasher OD); Woolcock

Institute of Medical Research (G B Marks PhD), University of Sydney, Sydney, NSW, Australia (J Leigh PhD, A B Mekonnen MS); Stockholm Centre for Health and Social Change, Södertörn University, Stockholm, Sweden (M Leinsalu PhD); State University of New York, Albany, Rensselaer, NY, USA (R Leung PhD); Tuscany Regional Centre for Occupational Injuries and Diseases, Florence, Italy (M Levi PhD); Chinese Center for Disease Control and Prevention, Beijing, China (Prof X Liang MD); University of Haifa, Haifa, Israel (Prof S Linn MD); School of Medicine, Wayne State University, Detroit, MI, USA (Prof S E Lipshultz MD, Prof J D Wilkinson MD); Children's Hospital of Michigan, Detroit, MI, USA (Prof S E Lipshultz MD, Prof J D Wilkinson MD); Emory University, Atlanta, GA, USA (Prof Y Liu PhD, Prof M R Phillips MD); UnionHealth Associates, LLC, St. Louis, MO, USA (L Lo MD); Alton Mental Health Center, Alton, IL, USA (L Lo MD); University of Bari, Bari, Italy (Prof G Logroscino PhD); Children's Hospital of Philadelphia, University of Pennsylvania School of Medicine, Philadelphia, PA, USA (S A Lorch MD); Aintree University Hospital National Health Service Foundation Trust, Liverpool, UK (Prof R Lunevicius PhD); School of Medicine, University of Liverpool, Liverpool, UK (Prof R Lunevicius PhD); Royal Children's Hospital, Melbourne, VIC, Australia (M T Mackay MBBS, R G Weintraub MBBS); Mansoura Faculty of Medicine, Mansoura, Egypt (H Magdy Abd El Razek MBBS); Aswan University Hospital, Aswan Faculty of Medicine, Aswan, Egypt (M Magdy Abd El Razek MBBS); Institute of Health Policy and Management, Erasmus University Rotterdam, Rotterdam, Netherlands (M Mahdavi PhD); Social Security Organization Research Institute, Tehran, Iran (M Mahdavi PhD); Faculdade de Medicina (Prof M A S Rego PhD), Universidade Federal de Minas Gerais, Belo Horizonte, Brazil (Prof D C Malta PhD); University of Milano Bicocca, Monza, Italy (Prof L G Mantovani DSc); Ethiopian Public Health Association, Addis Ababa, Ethiopia (T Manyazewal PhD); Division of Population and Patient Health, King's College London Dental Institute, London, UK (Prof W Marcenies PhD); Hospital Universitario Doctor Peset, Valencia, Spain (J Martinez-Raga PhD); CEU Cardinal Herrera University, Moncada, Spain (J Martinez-Raga PhD); University of the East Ramon Magsaysay Memorial Medical Center, Quezon City, Philippines (M B Marzan MSc); Hospital Pedro Hispano/UlS Matosinhos, Matosinhos, Portugal (J Massano MD); George Institute for Global Health India, New Delhi, India (P K Maulik PhD); Key State Laboratory of Molecular Developmental Biology, Institute of Genetics and Developmental Biology, Chinese Academy of Sciences, Beijing, China (M Mazidi PhD); University Hospitals Bristol NHS Foundation Trust, Bristol, UK (C McAlinden PhD); Public Health Wales, Swansea, UK (C McAlinden PhD); Perelman School of Medicine, University of Pennsylvania, Philadelphia, PA, USA (P A Meaney MD); Children's Hospital of Philadelphia, Philadelphia, PA, USA (P A Meaney MD); College of Medicine, Howard University, Washington, DC, USA (A Mehari MD); Janakpuri Superspecialty Hospital, New Delhi, India (Prof M M Mehndiratta DM); Martin Luther University Halle-Wittenberg, Halle (Saale), Germany (T Meier PhD); Saudi Ministry of Health, Riyadh, Saudi Arabia (Prof Z A Memish MD); College of Medicine, Alfaisal University, Riyadh, Saudi Arabia (Prof Z A Memish MD); Center for Translation Research and Implementation Science, National Heart, Lung, and Blood Institute, National Institutes of Health, Bethesda, MD, USA (G A Mensah MD); Department of Neurology (A Meretoja PhD), Comprehensive Cancer Center, Breast Surgery Unit (T J Meretoja PhD), Helsinki University Hospital, Helsinki, Finland; Friedman School of Nutrition Science and Policy (R Micha PhD), Tufts University, Boston, MA, USA (P Shi PhD); University of Ottawa, Ottawa, ON, Canada (E J Mills PhD); Hunger Action Los Angeles, Los Angeles, CA, USA (M Mirarefin MPH); Kyrgyz State Medical Academy, Bishkek, Kyrgyzstan (Prof E M Mirrakhimov PhD); National Center of Cardiology and Internal Disease, Bishkek, Kyrgyzstan (Prof E M Mirrakhimov PhD); University of Salahaddin, Erbil, Iraq (K A Mohammad PhD); Health Systems and Policy Research Unit, Ahmadu Bello University, Zaria, Nigeria (S Mohammed PhD); Reproductive Health and ObGyn School of Medicine and Health Sciences, University of Papua New Guinea, Boroko, Papua New Guinea (Prof G L D Mola DPH); Institute for Maternal and Child Health, IRCCS Burlo Garofolo, Trieste, Italy (L Monasta DSc, M Montico MSc, L Ronfani PhD); Department of Community Medicine, Gastrointestinal and Liver Disease Research Center (GILDRC), Preventative Medicine and Public Health Research Center (M Moradi-Lakeh MD), Preventive Medicine and Public Health Research Center (A Tehrani-Banihashemi PhD), Iran University of Medical Sciences, Tehran, Iran; International Laboratory for Air Quality and Health (L Morawska PhD), School of Public Health and Social Work (J Sun PhD), Queensland University of Technology, Brisbane, QLD, Australia (P Moraga PhD); National Center for Child Health and Development, Setagaya, Japan (R Mori PhD); Competence Center Mortality-Follow-Up of the German National Cohort (A Werdecker PhD), Federal Institute for Population Research, Wiesbaden, Germany (Prof U O Mueller PhD, R Westerman PhD); School of Medical Sciences, University of Science Malaysia, Kubang Kerian, Malaysia (K I Musa MD); Graduate School of Public Health, University of Pittsburgh, Pittsburgh, PA, USA (Prof J B Nachega PhD); Stellenbosch University, Cape Town, South Africa (Prof J B Nachega PhD, Prof S Seedat PhD, Prof C S Wiysonge PhD); Johns Hopkins Bloomberg School of Public Health, Baltimore, MD, USA (Prof J B Nachega PhD); National Center for Child Health and Development, Setagaya-ku, Japan (C Nagata PhD); Institute of Epidemiology and Medical Biometry (Prof D Rothenbacher MD), Ulm University, Ulm, Germany (Prof G Nagel PhD); Azienda Ospedaliera Papa Giovanni XXIII, Bergamo, Italy (Prof L Naldi MD); Suraj Eye Institute, Nagpur, India (V Nangia MD); Hospital das Clinicas da Universidade Federal de Minas Gerais, Belo Horizonte, Brazil (Prof B R Nascimento PhD, Prof A L Ribeiro MD); Hospital Universitário Ciências Médicas, Belo Horizonte, Brazil (Prof B R Nascimento PhD); Carol Davila University of Medicine and Pharmacy Bucharest, Bucharest, Romania (I Negoii PhD); KEMRI Wellcome Trust, Kilifi, Kenya (Prof C R Newton MD); Ministry of Health and Social Welfare, Dar es Salaam, Tanzania (F N Ngalesoni MSc); University of Nairobi, Nairobi, Kenya (J W Ngunjiri PhD); Department of Public Health, Semarang State University, Semarang City, Indonesia (D N A Ningrum MPH); Population Health Strategic Research Centre, School of Health and Social Development (S Nolte PhD), Deakin University, Burwood, VIC, Australia (Prof M A Stokes PhD); National Institute of Public Health, Saitama, Japan (M Nomura PhD); Medical Diagnostic Centre, Yaounde, Cameroon (J J N Noubiap MD); Center for Research on Population and Health, Faculty of Health Sciences, American University of Beirut, Beirut, Lebanon (Prof C M Obermeyer DSc); Centre for Health Research (F A Ogbo MPH), Western Sydney University, Penrith, NSW, Australia (Prof A M N Renzaho PhD); Department of Preventive Medicine, School of Medicine, Kyung Hee University, Seoul, South Korea (Prof I Oh PhD); Society for Family Health, Abuja, Nigeria (A Okoro MPH); Human Sciences Research Council (HSRC), South Africa and University of KwaZulu-Natal, Durban, South Africa (O Oladimeji MS); Universidad Autonoma de Chile, Talca, Chile (Prof P R Olivares PhD); Center for Healthy Start Initiative, Lagos, Nigeria (B O Oluasanya PhD, J O Oluasanya MBA); Lira District Local Government, Lira Municipal Council, Uganda (J N Opio MPH); University of Arizona, Tucson, AZ, USA (Prof E Oren PhD); IIS-Fundacion Jimenez Diaz-UAM, Madrid, Spain (Prof A Ortiz PhD); Population Health Strategic Research Centre, School of Health and Social Development (S Nolte PhD), Deakin University, Geelong, VIC, Australia (Prof R H Osborne PhD); YBank, Cambridge, MA, USA (M Osman MD); Department of Medicine, Ibadan, Nigeria (M O Owolabi Dr Med); Blossom Specialist Medical Center, Ibadan, Nigeria (M O Owolabi Dr Med); JSS Medical College, JSS University, Mysore, India (Prof M PA DNB); The Ottawa Hospital Research Institute, Ottawa, ON, Canada (S Pakhale MD); Ministry of Health, Mexico City, Mexico (E Palomares Castillo PhD); Universidad Nacional Autónoma de México (UNAM), Mexico City, Mexico (E Palomares Castillo PhD); Mount Sinai Health System, New York, NY, USA (T Patel MD); UK Department for International Development, Lalitpur, Nepal (D Paudel PhD); REQUIMTE/LAQV, Laboratório de Farmacognosia, Departamento de Química, Faculdade de Farmácia, Universidade do Porto, Porto, Portugal (Prof D M Pereira PhD); National Institute of Respiratory Diseases, Mexico City, Mexico (Prof R Perez-Padilla MD); Hopsital Universitario Cruces, OSI EE-Cruces, Baracaldo, Spain (F Perez-Ruiz PhD); Biocruces Health Research Institute, Baracaldo, Spain (F Perez-Ruiz PhD); Flinders University, Adelaide, SA, Australia (Prof K Pesudovs PhD); Health

Metrics Unit, University of Gothenburg, Gothenburg, Sweden (Prof M Petzold PhD); University of the Witwatersrand, Johannesburg, South Africa (Prof M Petzold PhD); Shanghai Jiao Tong University School of Medicine, Shanghai, China (Prof M R Phillips MD); Durban University of Technology, Durban, South Africa (J D Pillay PhD); University of Newcastle, Callaghan, NSW, Australia (Prof C D Pond PhD); Charotar University of Science and Technology, Anand, India (Prof V Prakash MPT); Intergrowth 21st Study Research Centre, Nagpur, India (Prof M Purwar MD); Non-communicable Diseases Research Center, Alborz University of Medical Sciences, Karaj, Iran (M Qorbani PhD); A T Still University, Kirksville, MO, USA (A Radfar MD); Contech International Health Consultants, Lahore, Pakistan (A Rafay MS, Prof S M Rana PhD); Contech School of Public Health, Lahore, Pakistan (A Rafay MS, Prof S M Rana PhD); Research and Evaluation Division, BRAC, Dhaka, Bangladesh (M Rahman PhD); Society for Health and Demographic Surveillance, Suri, India (R K Rai MPH); Diabetes Research Society, Hyderabad, India (Prof P V Rao MD); Diabetes Research Center, Hyderabad, India (Prof P V Rao MD); Azienda Socio-Sanitaria Territoriale, Papa Giovanni XXIII, Bergamo, Italy (Prof G Remuzzi MD); Department of Biomedical and Clinical Sciences L. Sacco, University of Milan, Milan, Italy (Prof G Remuzzi MD); Brien Holden Vision Institute (Prof S Resnikoff MD), School of Optometry and Vision Science (Prof S Resnikoff MD), University of New South Wales, Randwick, NSW, Australia (Prof P S Sachdev MD); Golestan Research Center of Gastroenterology and Hepatology, Golestan University of Medical Sciences, Gorgan, Iran (G Roshandel PhD); Holmusk, Singapore, Singapore (N K Roy MS); Duke-NUS Medical School, Singapore, Singapore (N K Roy MS); Prince of Wales Hospital, Randwick, NSW, Australia (Prof P S Sachdev MD); World Health Organization, Accra, Ghana (B B Saeky MS); Ministry of Health, Riyadh, Saudi Arabia (M Y Saeedi PhD); Managerial Epidemiology Research Center, Maragheh University of Medical Sciences, Maragheh, Iran (S Safiri PhD); Development Research and Projects Center, Abuja, Nigeria (M M Saleh MPH); Ain Shams University, Cairo, Egypt (A M Samy PhD); J Edwards School of Medicine, Marshall University, Huntington, WV, USA (J R Sanabria MD); Case Western Reserve University, Cleveland, OH, USA (J R Sanabria MD); IIS-Fundacion Jimenez Diaz, Madrid, Spain (M D Sanchez-Niño PhD); Universidad Ciencias Aplicadas y Ambientales, Bogotá, Colombia (R Sarmiento-Suarez MPH); Public Health Medicine, School of Nursing and Public Health (Prof B Sartorius PhD), Discipline of Public Health Medicine, School of Nursing and Public Health (B Yakob PhD), University of KwaZulu-Natal, Durban, South Africa; UKZN Gastrointestinal Cancer Research Centre, South African Medical Research Council (SAMRC), Cape Town, South Africa (Prof B Sartorius PhD); Marshall University, Huntington, WV, USA (M Sawhney PhD); Bayer Turkey, Istanbul, Turkey (M I Saylan PhD); Institute of Health Care and Social Sciences, FOM University, Essen, Germany (B Schöttker MPH); Hypertension in Africa Research Team (HART), North-West University, Potchefstroom, South Africa (Prof A E Schutte PhD); South African Medical Research Council, Potchefstroom, South Africa (Prof A E Schutte PhD); University of Colorado, Aurora, CO, USA (B Serdar PhD); Department of Public Health, An-Najah University, Nablus, Palestine (A Shaheen PhD); Tufts Medical Center, Boston, MA, USA (Prof S Shahrzad PhD); Independent Consultant, Karachi, Pakistan (M A Shaikh MD); Ministry of Health, Thimphu, Bhutan (J Sharma MPH); Indian Institute of Technology Ropar, Rupnagar, India (R Sharma MA); Research Institute at Nationwide Children's Hospital, Columbus, OH, USA (J Shen PhD); National Institute of Infectious Diseases, Tokyo, Japan (M Shigematsu PhD); Sandia National Laboratories, Albuquerque, NM, USA (M Shigematsu PhD); Department of Public Health Science, Graduate School (Prof M Shin PhD), Department of Preventive Medicine, College of Medicine (S Yoon PhD), Korea University, Seoul, South Korea; Imperial College London, UK (H Shoman MPH); Reykjavik University, Reykjavik, Iceland (I D Sigfusdottir PhD); Federal University of Santa Catarina, Florianópolis, Brazil (D A S Silva PhD); Brasília University, Brasília, Brazil (D G A Silveira MD); University of Alabama at Birmingham and Birmingham Veterans Affairs Medical Center, Birmingham, AL, USA (J A Singh MD); Department of Medicine, Institute of Medical Sciences, Banaras Hindu University, Varanasi, India (O P Singh PhD); Institute for Human Development, New Delhi, India (P K Singh PhD); Asthma Bhawan, Jaipur, India (V Singh MD); Ethiopian Medical Association, Addis Ababa, Ethiopia (A H Sinke MD); University of Gondar, Ethiopia, Gondar, Ethiopia (A E Sinshaw MS); University of Yaoundé, Yaoundé, Cameroon (Prof E Sobngwi PhD); Yaoundé Central Hospital, Yaoundé, Cameroon (Prof E Sobngwi PhD); Dartmouth College, Hanover, NH, USA (S Soneji PhD); Instituto de Investigación Hospital Universitario de la Princesa, Universidad Autónoma de Madrid, Madrid, Spain (Prof J B Soriano PhD); National School of Public Health/Oswaldo Cruz Foundation, Rio de Janeiro, Brazil (Prof T C M Sousa MPH); Department of Clinical Neurological Sciences, Western University, London, ON, Canada (L A Sposato MD); Department of Community Medicine, International Medical University, Kuala Lumpur, Malaysia (C T Sreeramareddy MD); Attikon University Hospital, Athens, Greece (V Stathopoulou PhD); University of East Anglia, Norwich, UK (Prof N Steel PhD); Department of Dermatology, University Hospital Muenster, Muenster, Germany (S Steinke DrMed); School of Health and Related Research, University of Sheffield, Sheffield, UK (M Strong PhD); Alexandra General Hospital of Athens, Athens, Greece (K Stroumpoulis PhD); Centre Hospitalier Public du Cotentin, Cherbourg, France (K Stroumpoulis PhD); Ahmadu Bello University, Zaria, Zaria, Nigeria (M B Sufiyan MBA); Ministry of Health, Kingdom of Saudi Arabia, Riyadh, Saudi Arabia (R A Suliankatchi MD); University of Southern Queensland, Institute for Resilient Regions, Springfield, QLD, Australia (J Sun PhD); Indian Council of Medical Research, Chennai, India (S Swaminathan MD); Departments of Criminology, Law & Society, Sociology, and Public Health, University of California, Irvine, Irvine, CA, USA (Prof B L Sykes PhD); Department of Medicine, University of Valencia, INCLIVA Health Research Institute and CIBERSAM, Valencia, Spain (Prof R Tabarés-Seisdedos PhD); School of Social Work, University of Illinois at Urbana-Champaign, Champaign, IL, USA (K M Tabb PhD); Ministry of Health, MINSANTE, Yaounde, Cameroon (R T Talongwa MD); Instituto Conmemorativo Gorgas de Estudios de la Salud, Panama City, Panama (M Tarajia MD); New York Medical Center, Valhalla, NY, USA (M Tavakkoli MD); Instituto Superior de Ciências da Saúde Egas Moniz, Almada, Portugal (Prof N Taveira PhD); Faculty of Pharmacy, Universidade de Lisboa, Lisboa, Portugal (Prof N Taveira PhD); University of Newcastle, Newcastle, New South Wales, Australia (T Tekelab MS); Arba Minch University, Arba Minch, Ethiopia (G Temam Shifa MPH); Department of Anesthesiology, University of Virginia, Charlottesville, VA, USA (A S Terkawi MD); Department of Anesthesiology, King Fahad Medical City, Riyadh, Saudi Arabia (A S Terkawi MD); Outcomes Research Consortium, Cleveland Clinic, Cleveland, OH, USA (A S Terkawi MD); School of Public Health, Post Graduate Institute of Medical Education and Research, Chandigarh, India (Prof J Thakur MD); Adaptive Knowledge Management, Victoria, BC, Canada (A J Thomson PhD); National Center for Child Health and Development, Tokyo, Japan (R Tobe-Gai PhD); University of Calgary, Calgary, AB, Canada (Prof M Tonelli MD); Institute of Public Health, Faculty of Health Sciences, Jagiellonian University Medical College, Kraków, Poland (R Topor-Madry PhD); Faculty of Health Sciences, Wrocław Medical University, Wrocław, Poland (R Topor-Madry PhD); Hospital Universitario Dr. Peset, Valencia, Spain (M Tortajada PhD); Department of Neurology, Rigshospitalet, University of Copenhagen, Copenhagen, Denmark (T Truelsen DMSc); Department of Veterans Affairs, Washington DC, DC, USA (U S Uchendu MD); Department of Internal Medicine, Federal Teaching Hospital, Abakaliki, Nigeria (K N Ukwaja MD); Brandeis University, Waltham, MA, USA (E A Undurraga PhD); Ebonyi State University, Abakaliki, Nigeria (C J Uneke PhD); Warwick Medical School, University of Warwick, Coventry, UK (O A Uthman PhD); Joint Research Centre, European Commission, Ispra, Italy (R Van Dingenen PhD); UKK Institute for Health Promotion Research, Tampere, Finland (Prof T Vasankari PhD); Raffles Neuroscience Centre, Raffles Hospital, Singapore, Singapore (N Venketasubramanian FRCP); University of Bologna, Bologna, Italy (Prof F S Violante MD); Federal Research Institute for Health Organization and Informatics, Moscow, Russia (S K Vladimirov PhD); National Research University Higher School of Economics, Moscow, Russia (Prof V V Vlassov MD); Uniformed Services University of Health

Sciences, Bethesda, MD, USA (Prof S G Waller MD); Natural History Museum, London, UK (J L Walson MD); University of Sao Paulo Medical School, Sao Paulo, Brazil (Y Wang PhD); Department of Research, Cancer Registry of Norway, Institute of Population-Based Cancer Research, Oslo, Norway (E Weiderpass PhD); Department of Community Medicine, Faculty of Health Sciences, University of Tromsø, The Arctic University of Norway, Tromsø, Norway (E Weiderpass PhD); Genetic Epidemiology Group, Folkhälsan Research Center, Helsinki, Finland (E Weiderpass PhD); Ghent University, Ghent, Belgium (J Wesana MPH); Mountains of the Moon University, Fort Portal, Uganda (J Wesana MPH); German National Cohort Consortium, Heidelberg, Germany (R Westerman PhD); South African Medical Research Council, Cochrane South Africa, Cape Town, South Africa (Prof C S Wiysonge PhD); National Institute for Health Research Comprehensive Biomedical Research Centre, Guy's & St Thomas' NHS Foundation Trust and King's College London, London, UK (Prof C D Wolfe MD); Ghent University, Ghent, Belgium (A Workicho MPH); Wolaita Sodo University, Wolaita Sodo, Ethiopia (S B Workie MPH); St Paul's Hospital Millennium Medical College, Addis Ababa, Ethiopia (M Wubshet Terefe PhD); Addis Continental Institute of Public Health, Addis Ababa, Ethiopia (M Wubshet Terefe PhD); St. John's Medical College and Research Institute, Bangalore, India (Prof D Xavier MD); Department of Neurology, Jinling Hospital, Nanjing University School of Medicine, Nanjing, China (Prof G Xu PhD); University of Saskatchewan, Saskatoon, SK, Canada (M Yaghoubi MA); Global Health Research Center, Duke Kunshan University, Kunshan, China (Prof L L Yan PhD); Department of Preventive Medicine, Northwestern University, Chicago, IL, USA (Y Yano MD); Uro-Oncology Research Center (E Amini MD), Endocrinology and Metabolism Population Sciences Institute (Prof A Esteghamati MD, S Sheikhbahaee MD), Non-Communicable Diseases Research Center (F Farzadfar MD, M Parsaeian PhD), Endocrinology and Metabolism Research Center (N Hafezi-Nejad MD), Center for Air Pollution Research, Institute for Environmental Research (M S Hassanvand PhD), Hematology-Oncology and Stem Cell Transplantation Research Center (A Kasaeian PhD), Digestive Diseases Research Institute (Prof R Malekzadeh MD, G Roshandel PhD, S G Sepanlou PhD), Sina Trauma and Surgery Research Center (Prof V Rahimi-Movaghar MD), MS Research Center, Neuroscience Institute (M A Sahraian MD), Institute for Environmental Research (M Shamsipour PhD), Tehran University of Medical Sciences, Terhan, Iran (M Yaseri PhD); Social Work and Social Administration Department (Prof P Yip PhD), The Hong Kong Jockey Club Centre for Suicide Research and Prevention (Prof P Yip PhD), University of Hong Kong, Hong Kong, China; Department of Biostatistics, School of Public Health, Kyoto University, Kyoto, Japan (N Yonemoto MPH); Jackson State University, Jackson, MS, USA (Prof M Z Younis DrPH); Department of Epidemiology and Biostatistics, School of Public Health (Prof C Yu PhD), Global Health Institute (Prof C Yu PhD), Wuhan University, Wuhan, China; University Hospital, Setif, Algeria (Prof Z Zaidi PhD); Faculty of Medicine, Mansoura University, Mansoura, Egypt (Prof M E Zaki PhD); EcoHealth Alliance, New York, NY, USA (C Zambrana-Torrel MSc); Instituto de Ecología-Bolivia, La Paz, Bolivia (C Zambrana-Torrel MSc); World Health Organization, Windhoek, Namibia (T Zapata MD); and Red Cross War Memorial Children's Hospital, Cape Town, South Africa (L J Zuhlke PhD).

Contributors

CJLM and NF prepared the first draft of the report. RMB conducted risk-standardisation analyses, computed indices, and led sensitivity analyses. RJDS developed methods for the frontier analysis. CJLM conceived of this study and provided overall guidance, with key inputs from TB, MM, and EN. CJLM and NF finalised the manuscript based on reviewer feedback. All other authors provided data or developed models, reviewed results, initiated modelling infrastructure, or reviewed and contributed to this manuscript.

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References

- United Nations. Transforming our World: the 2030 Agenda for Sustainable Development. New York, NY, USA: UN, 2015.
- Tobias M, Yeh L-C. How much does health care contribute to health gain and to health inequality? Trends in amenable mortality in New Zealand 1981–2004. *Aust N Z J Public Health* 2009; **33**: 70–78.
- Gay JG, Paris V, Devaux M, de Looper M. Mortality Amenable to Health Care in 31 OECD Countries. Paris: Organisation for Economic Co-operation and Development, 2011. <http://www.oecd-ilibrary.org/content/workingpaper/5kgj35f9f8s2-en> (accessed Dec 23, 2016).
- Nolte E, McKee M. Does healthcare save lives? Avoidable mortality revisited. London, UK: Nuffield Trust, 2004.
- Murray CJ, Lopez AD. On the comparable quantification of health risks: lessons from the Global Burden of Disease Study. *Epidemiol Camb Mass* 1999; **10**: 594–605.
- Rutstein DD, Berenberg W, Chalmers TC, et al. Measuring the Quality of Medical Care. *N Engl J Med* 1976; **294**: 582–88.
- Charlton JR, Velez R. Some international comparisons of mortality amenable to medical intervention. *Br Med J Clin Res Ed* 1986; **292**: 295–301.
- Holland W. Avoidable death as a measure of quality. *Int J Qual Health Care* 1990; **2**: 227–33.
- Nolte E, McKee M. Measuring the health of nations: analysis of mortality amenable to health care. *BMJ* 2003; **327**: 1129.
- Treurniet HF, Bosshuizen HC, Harteloh PPM. Avoidable mortality in Europe (1980–1997): a comparison of trends. *J Epidemiol Community Health* 2004; **58**: 290–95.
- Nolte E, McKee M. Variations in amenable mortality—trends in 16 high-income nations. *Health Policy Amst Neth* 2011; **103**: 47–52.
- Petrie D, Tang KK. Relative health performance in BRICS over the past 20 years: the winners and losers. *Bull World Health Organ* 2014; **92**: 396–404.

- 13 McKeown T. The role of medicine: dream, mirage or nemesis? Oxford, UK: Blackwell, 1979.
- 14 Illich I. Medical Nemesis: the Appropriation of Health. London, UK: Calder and Boyars, 1975.
- 15 McKinlay JB, McKinlay SM. The questionable contribution of medical measures to the decline of mortality in the United States in the twentieth century. *Milbank Mem Fund Q Health Soc* 1977; **55**: 405–28.
- 16 Mackenbach JP. The contribution of medical care to mortality decline: McKeown revisited. *J Clin Epidemiol* 1996; **49**: 1207–13.
- 17 Dye C, Fengzeng Z, Scheele S, Williams B. Evaluating the impact of tuberculosis control: number of deaths prevented by short-course chemotherapy in China. *Int J Epidemiol* 2000; **29**: 558–64.
- 18 Borgdorff MW, Floyd K, Broekmans JF. Interventions to reduce tuberculosis mortality and transmission in low- and middle-income countries. *Bull World Health Organ* 2002; **80**: 217–27.
- 19 Koenig MA, Khan MA, Wojtyniak B, et al. Impact of measles vaccination on childhood mortality in rural Bangladesh. *Bull World Health Organ* 1990; **68**: 441–47.
- 20 Campbell OM, Graham WJ. Strategies for reducing maternal mortality: getting on with what works. *Lancet* 2006; **368**: 1284–99.
- 21 Adam T, Lim SS, Mehta S, et al. Cost effectiveness analysis of strategies for maternal and neonatal health in developing countries. *BMJ* 2005; **331**: 1107.
- 22 Richards MA, Stockton D, Babb P, Coleman MP. How many deaths have been avoided through improvements in cancer survival? *BMJ* 2000; **320**: 895–98.
- 23 Stockton D, Davies T, Day N, McCann J. Retrospective study of reasons for improved survival in patients with breast cancer in east Anglia: earlier diagnosis or better treatment. *BMJ* 1997; **314**: 472–75.
- 24 Ebrahim S, Harwood R. Stroke: Epidemiology, Evidence and Clinical Practice, 2nd edn. Oxford; New York: Oxford University Press, 1999.
- 25 Nolte E, Bain C, McKee M. Diabetes as a tracer condition in international benchmarking of health systems. *Diabetes Care* 2006; **29**: 1007–11.
- 26 Tonelli M, Wiebe N, Culleton B, et al. Chronic kidney disease and mortality risk: a systematic review. *J Am Soc Nephrol* 2006; **17**: 2034–47.
- 27 Rutstein DD, Berenberg W, Chalmers TC, Fishman AP, Perrin EB, Zuidema GD. Measuring the quality of medical care: second revision of tables of indexes. *N Engl J Med* 1980; **302**: 1146.
- 28 Holland WW. The 'avoidable death' guide to Europe. *Health Policy* 1986; **6**: 115–17.
- 29 Mackenbach JP, Looman CW, Kunst AE, Habbema JD, van der Maas PJ. Post-1950 mortality trends and medical care: gains in life expectancy due to declines in mortality from conditions amenable to medical intervention in The Netherlands. *Soc Sci Med* 1988; **27**: 889–94.
- 30 Nolte E, McKee CM. Measuring the health of nations: updating an earlier analysis. *Health Aff (Millwood)* 2008; **27**: 58–71.
- 31 Nolte E, McKee CM. In amenable mortality—deaths avoidable through health care—progress in the US lags that of three European countries. *Health Aff (Millwood)* 2012; **31**: 2114–22.
- 32 Manuel DG, Mao Y. Avoidable Mortality in the United States and Canada, 1980–1996. *Am J Public Health* 2002; **92**: 1481–84.
- 33 Niti M, Ng TP. Temporal trends and ethnic variations in amenable mortality in Singapore 1965–1994: the impact of health care in transition. *Int J Epidemiol* 2001; **30**: 966–73.
- 34 OECD. Health at a Glance: Europe 2016. State of the Health in the EU Cycle. Paris, France: Organisation for Economic Cooperation and Development, 2016.
- 35 Nolte E, Scholz R, Shkolnikov V, McKee M. The contribution of medical care to changing life expectancy in Germany and Poland. *Soc Sci Med* 2002; **55**: 1905–21.
- 36 Kelson M, Farebrother M. The effect of inaccuracies in death certification and coding practices in the European Economic Community (EEC) on international cancer mortality statistics. *Int J Epidemiol* 1987; **16**: 411–14.
- 37 Mackenbach JP. Health care expenditure and mortality from amenable conditions in the European Community. *Health Policy Amst Neth* 1991; **19**: 245–55.
- 38 Poikolainen K, Eskola J. Health services resources and their relation to mortality from causes amenable to health care intervention: a cross-national study. *Int J Epidemiol* 1988; **17**: 86–89.
- 39 Pampalon R. Avoidable mortality in Québec and its regions. *Soc Sci Med* 1982 1993; **37**: 823–31.
- 40 Mackenbach JP, Kunst AE, Looman CW, Habbema JD, van der Maas PJ. Regional differences in mortality from conditions amenable to medical intervention in The Netherlands: a comparison of four time periods. *J Epidemiol Community Health* 1988; **42**: 325–32.
- 41 Harris AR, Thomas SH, Fisher GA, Hirsch DJ. Murder and medicine: the lethality of criminal assault 1960–1999. *Homicide Stud* 2002; **6**: 128–66.
- 42 Lecky F, Woodford M, Yates D. Trends in trauma care in England and Wales 1989–97. *Lancet* 2000; **355**: 1771–75.
- 43 Modig K, Andersson T, Drefahl S, Ahlbom A. Age-specific trends in morbidity, mortality and case-fatality from cardiovascular disease, myocardial infarction and stroke in advanced age: evaluation in the Swedish population. *PLoS One* 2013; **8**: e64928.
- 44 Endreseth BH, Romundstad P, Myrvold HE, Bjerkeset T, Wibe A, The Norwegian Rectal Cancer Group. Rectal cancer treatment of the elderly. *Colorectal Dis* 2006; **8**: 471–79.
- 45 The Primary Health Care Performance Initiative (PHCPI). Coverage Index. Sept 17, 2015. <http://phcperformanceinitiative.org/indicator/coverage-index> (accessed Dec 23, 2016).
- 46 International Labour Organization. World Social Security Report 2010/2011: Providing coverage times of crisis and beyond. Geneva, Switzerland: International Labour Organization, 2010.
- 47 Wang H, Naghavi M, Allen C, et al. Global, regional, and national life expectancy, all-cause mortality, and cause-specific mortality for 249 causes of death, 1980–2015: a systematic analysis for the Global Burden of Disease Study 2015. *Lancet* 2016; **388**: 1459–544.
- 48 Forouzanfar MH, Afshin A, Alexander LT, et al. Global, regional, and national comparative risk assessment of 79 behavioural, environmental and occupational, and metabolic risks or clusters of risks, 1990–2015: a systematic analysis for the Global Burden of Disease Study 2015. *Lancet* 2016; **388**: 1659–724.
- 49 Vos T, Allen C, Arora M, et al. Global, regional, and national incidence, prevalence, and years lived with disability for 310 diseases and injuries, 1990–2015: a systematic analysis for the Global Burden of Disease Study 2015. *Lancet* 2016; **388**: 1545–602.
- 50 Kassebaum NJ, Arora M, Barber RM, et al. Global, regional, and national disability-adjusted life-years (DALYs) for 315 diseases and injuries and healthy life expectancy (HALE), 1990–2015: a systematic analysis for the Global Burden of Disease Study 2015. *Lancet* 2016; **388**: 1603–58.
- 51 Naghavi M, Makela S, Foreman K, O'Brien J, Pourmalek F, Lozano R. Algorithms for enhancing public health utility of national causes-of-death data. *Popul Health Metr* 2010; **8**: 9.
- 52 Stevens GA, Alkema L, Black RE, et al. Guidelines for Accurate and Transparent Health Estimates Reporting: the GATHER statement. *Lancet* 2016; **388**: e19–e23.
- 53 Lozano R, Naghavi M, Foreman K, et al. Global and regional mortality from 235 causes of death for 20 age groups in 1990 and 2010: a systematic analysis for the Global Burden of Disease Study 2010. *Lancet* 2012; **380**: 2095–128.
- 54 Forouzanfar MH, Alexander L, Anderson HR, et al. Global, regional, and national comparative risk assessment of 79 behavioural, environmental and occupational, and metabolic risks or clusters of risks in 188 countries, 1990–2013: a systematic analysis for the Global Burden of Disease Study 2013. *Lancet* 2015; **386**: 2287–323.
- 55 Lim SS, Vos T, Flaxman AD, et al. A comparative risk assessment of burden of disease and injury attributable to 67 risk factors and risk factor clusters in 21 regions, 1990–2010: a systematic analysis for the Global Burden of Disease Study 2010. *Lancet* 2012; **380**: 2224–60.
- 56 Lim SS, Allen K, Bhutta ZA, et al. Measuring the health-related Sustainable Development Goals in 188 countries: a baseline analysis from the Global Burden of Disease Study 2015. *Lancet* 2016; **388**: 1813–50.
- 57 WHO. Global Health Observatory. World Health Organization. <http://www.who.int/gho/database/en/> (accessed Sept 10, 2015).
- 58 Bogetoft P, Otto L. Benchmarking with data envelopment analysis, stochastic frontier analysis, and R, 2011 edition. New York, NY, USA: Springer, 2013.
- 59 Hwang S-N, Lee H-S, Zhu J. Handbook of operations analytics using data envelopment analysis. Berlin: Springer, 2016.

- 60 Smith OK, Cortez RA, Tandon A, Nagpal S, Cotlear D. Going universal: how 24 developing countries are implementing universal health coverage reforms from the bottom up. The World Bank, 2015. <http://documents.worldbank.org/curated/en/936881467992465464/Going-universal-how-24-developing-countries-are-implementing-universal-health-coverage-reforms-from-the-bottom-up> (accessed Dec 3, 2016).
- 61 IAEG-SDGs. Report of the Inter-Agency and Expert Group on the Sustainable Development Goal Indicators. Economic and Social Council, 2016 <http://unstats.un.org/unsd/statcom/47th-session/documents/2016-2-SDGs-Rev1-E.pdf> (accessed Nov 18, 2016).
- 62 McKee M, Nolte E. Measuring and evaluating performance. In: Health systems in low- and middle-income countries. Oxford, UK: Oxford University Press, 2011.
- 63 Risso-Gill I, Balabanova D, Majid F, et al. Understanding the modifiable health systems barriers to hypertension management in Malaysia: a multi-method health systems appraisal approach. *BMC Health Serv Res* 2015; **15**: 254.
- 64 Burki TK. Radiotherapy challenges in Uganda. *Lancet Oncol* 2016; **17**: e185.
- 65 Schoen C, Osborn R, Huynh PT, et al. Primary Care And Health-system performance: Adults' Experiences In Five Countries. *Health Aff (Millwood)* 2004; published online Oct 28. DOI:10.1377/hlthaff.w4.487.
- 66 Bartlett JA, DeMasi R, Quinn J, Moxham C, Rousseau F. Overview of the effectiveness of triple combination therapy in antiretroviral-naïve HIV-1 infected adults. *AIDS* 2001; **15**: 1369–77.
- 67 Baird JK. Effectiveness of antimalarial drugs. *N Engl J Med* 2005; **352**: 1565–77.
- 68 Group IAS. Artesunate combinations for treatment of malaria: meta-analysis. *Lancet* 2004; **363**: 9–17.
- 69 Strader DB, Wright T, Thomas DL, Seeff LB. Diagnosis, management, and treatment of hepatitis C. *Hepatology* 2004; **39**: 1147–71.
- 70 WHO. The World Health Report 2000. Health systems: improving performance. Geneva, Switzerland: World Health Organization, 2000.
- 71 McKee M. The World Health Report 2000: 10 years on. *Health Policy Plan* 2010; **25**: 346–8.
- 72 Morris S, Hunter RM, Ramsay AIG, et al. Impact of centralising acute stroke services in English metropolitan areas on mortality and length of hospital stay: difference-in-differences analysis. *BMJ* 2014; **349**: g4757.
- 73 Merali HS, Lipsitz S, Hevelone N, et al. Audit-identified avoidable factors in maternal and perinatal deaths in low resource settings: a systematic review. *BMC Pregnancy Childbirth* 2014; **14**: 280.
- 74 Jamison DT, Summers LH, Alleyne G, et al. Global health 2035: a world converging within a generation. *Lancet* 2013; **382**: 1898–955.
- 75 Mackenbach JP, McKee M. A comparative analysis of health policy performance in 43 European countries. *Eur J Public Health* 2013; **23**: 195–201.
- 76 Halstead S, Walsh J, Warren K. Good health at low cost. Bellagio: Rockefeller Foundation, 1985.
- 77 Campbell DT, Fiske DW. Convergent and discriminant validation by the multitrait-multimethod matrix. *Psychol Bull* 1959; **56**: 81–105.
- 78 Carmines EG, Zeller RA. Reliability and Validity Assessment. Beverly Hills, CA, USA and London, UK: SAGE Publications, 1979.
- 79 McCarthy D, Radley D, Hayes S. Aiming higher: results from a scorecard on state health-system performance, 2015 Edition. Washington DC: The Commonwealth Fund, 2015.